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Assess Effect of Vermicompost and Iron Nano Fertilizer on Morphological Traits and Chlorophyll Content of *Zea mays* L.

Najmeh Razmandeh[1], Saeed Zakernejad*[2], Khoshnaz Payandeh[3]

1- Msc. Graduated, Department of Agronomy, Ahvaz branch, Islamic Azad University, Ahvaz, Iran.
2- Department of Agronomy, Ahvaz branch, Islamic Azad University, Ahvaz, Iran.
3- Department of Soil Science, Ahvaz branch, Islamic Azad University, Ahvaz, Iran.

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ABSTRACT

BACKGROUND: In organic agriculture, one management goal is to increase and maintain soil quality with a high biological activity. Organic cropping system often has to deal with a scarcity of readily available nutrients in contrast to high input cropping system which relies widely available on soluble fertilizers. Nanotechnology such as using Nanoscale fertilizer particles may offer new techniques in improving existing crop management.

OBJECTIVES: Current study was carried out to assess effect of different level of vermicompost and Nano iron fertilizer on morphological characteristics, chlorophyll content and crop production of corn.

METHODS: This research was conducted according split plot experiment based on randomized complete blocks design with three replications along 2018 year in research farm of Islamic Azad University of Ahvaz Branch. Main plot included three level of vermicompost (V_0: nonuse of vermicompost or control, V_1: 5 t.ha^{-1} vermicompost, V_2: 10 t.ha^{-1} vermicompost) was consumed at planting stage. Also subplots consisted four level of Nano iron fertilizer (F_0: Nonuse of Nano iron fertilizer or control, F_1: 0.002 L.ha^{-1}, F_2: 0.004 L.ha^{-1} and F_3: 0.006 L.ha^{-1} Nano iron fertilizer) was used at 3 to 4 leaves stage.

RESULT: According result of analysis of variance effect of different level of vermicompost and iron Nano fertilizer on all studied traits was significant but interaction effect of treatments only on ear loss length was not significant. Assess mean comparison of interaction effect of treatments on all measured traits revealed the highest amount of seed yield (545.7 gr.m^{-2}), plant height (273.6 cm), Stem diameter (22.67 mm) ear length (26.73 cm), ear diameter (67.57 mm) and Chlorophyll index (2.951 spad) were noted for V_2F_3 treatment and lowest amount of mentioned traits belonged to control.

CONCLUSION: Use 10 t.ha^{-1} vermicompost with 0.006 L.ha^{-1} iron Nano fertilizer led to produce the highest amount of crop production, morphological traits and chlorophyll content and can be advice to farmers.

KEYWORDS: *Corn, Ear length, Nutrition, Plant height, Stem diameter.*

***Corresponding Author:** Saeed Zakernejad ✉ Zakernezhad48@yahoo.com

1. BACKGROUND

Fertilizer management is one of the most important factors in successful cultivation of crops affecting yield quality and quantity (Tahmasbi *et al.*, 2011). Chemical fertilizers are significant to succor nutrients in soil. Heavy doses of chemical fertilizers and pesticides are commonly used in order to enhance corn yields. Excessive nitrogen content in soil causes an inappropriate high uptake of this macronutrient by plants, which may result in inadequate growth and development due to the accumulation of nitrogen compounds in plant tissue (Szulc, 2013). Vermicompost is an organic compound that is microbial active and rich in nutrients that results from the interaction of earthworms and microorganisms with organic matter decomposition. It has been shown that these pitched and homogeneous materials have high porosity, adequate ventilation and drainage, and high water retention capacity, and contain nutrients found in the plant's absorbable form (Koozehgar kaleji and Ardakani, 2017). One of the most important symbiosis relations in the world of life that emerged during the evolutionary period is the mycorrhizal symbiosis, in which the roots of the plant with the fungus act as a unit of life and benefit from each other and grow to Each other (Naseri *et al.*, 2016). Several reports have been reported on the changes in nutrients resulting from bio-activity in the plant's rhizosphere and the increase in nutrient stores in the seeds, Song (2005) stated that by induction of mycorrhizal fungus, the environment around the plant root, the system. The roots develop and improve the absorption of water and nutrients. Mycorrhizal fungus helps to absorb nutrients by extending the root system of the plant and exploring the soil by external hair follicles in the hair roots and reducing the nutrients of that area (Khosrojerdi *et al*., 2013). Sharda Waman *et al*., 2009) showed that using inoculum fluid separately and in a combination of G. intaradices and G. mosseae increased potassium in the plant. Sajadi Nic *et al*. (2011) showed that chemical fertilizers, vermicompost, and biofertilizer absorb nutrients, proteins and seed yields. The results of these researchers showed that vermicompost consumption significantly increases the absorption of nitrogen, phosphorus and potassium elements. Darzi *et al*. (2011) stated that the addition of vermicompost to soil not only increased the nutrient content of the plant but also improved the physical and physical conditions of the soil, creating an appropriate growth medium the root causes increased shoot growth and dry matter production and finally improved seed yield. Application of vermicompost increases the total organic carbon, total nitrogen, phosphorus, potassium, and zinc and reduces the acidity of the soil. Vermicompost also improves porosity and soil compaction (Azarmi *et al.*, 2008). Iron deficiency has increased from 30% in the 1960s to 40% in the 1990s among the world population (Welch and Graham, 2002). The deficiency of iron in the soil causes reduction in wheat seed and quality leading to nutrition disorder (Fe deficiency) in human (Ghorbani *et al.*, 2009). Several

approaches were taken to cope with Fe deficiency in wheat seed. Abbas *et al*. (2009) applied 0, 4, 8, 12 and 12 kg.ha^{-1} in the form of iron sulphate to the soil and showed that iron fertilization increased Fe and protein contents of the wheat seed. With application of 150 g.ha^{-1} iron in the form of Fe_2O_3, Habib (2009) reported that iron and protein contents of the wheat seed were enhanced. Zeidan *et al.* (2010) applied foliar Fe fertilizer (1.0% $FeSO_4$) and reported that Fe application increased protein and Fe contents of wheat seed. In addition, the effectiveness of inorganic and chelated forms of Fe fertilizers ($FeSO_4$, Fe EDTA, Fe DTPA, Fe EDDHA, Fe-citrate) in overcoming Fe deficiency is highly variable depending on their solubility, stability, penetration ability through leaf cuticle, mobility and translocation following diffusion into the leaf tissues (Schonherr *et al.*, 2005; Fernandez *et al.*, 2009). Reduction of particle size results in increased number of particles per unit of weight and specific surface area of a fertilizer that should increase contact of fertilizer with plant leading to increase in nutrient uptake (Liscano *et al.*, 2000). Below 100 nm nano-particles could make plants use fertilizer more efficiently, reduced pollution and more environmentally friendly, dissolve in water more effectively thus increase their activities (Joseph and Morrison, 2006). Therefore, nanotechnology such as using nano-scale fertilizer particles may offer new techniques in improving existing crop management. Liu *et al.* (2005) reported that nano-Fe_2O_3 promoted the growth and photosynthesis of peanut. Sheykhbaglou *et al*. (2010) showed that application of nano-iron oxide particles increased soybean yield. Prasad *et al*. (2012) reported that nano-scale zinc oxide particles increased stem and root growth and pod yield of peanut as compared with $ZnSO_4$ application. Iron compound can use as foliar on leaves and seed coating (Debermann, 2006). There are a few reviews about the effects of nano-particles on plants. Studies showed that the effect of nano-particles on plants can be beneficial (seedling growth and development) or non-beneficial (to prevent root growth) (Zhu *et al.*, 2008). Several approaches were taken to cope with Fe deficiency in wheat seed.

2. OBJECTIVES

Current study was carried out to assess effect of different level of vermicompost and Nano iron fertilizer on morphological characteristics, chlorophyll content and crop production of corn.

3. MATERIALS AND METHODS

3.1. Field and Treatments Information

This research was conducted according split plot experiment based on randomized complete blocks design with three replications along 2018 year in research farm of Islamic Azad University of Ahvaz Branch. Place of research was located in Vis city at longitude 48°40'E and latitude 31°20'N in Khuzestan province (Southwest of Iran). Main plot included three level of vermicompost (V_0: nonuse of vermicompost or control, V_1: 5 t.ha^{-1} vermicompost, V_2: 10 t.ha^{-1} vermicompost)

was consumed at planting stage. Also subplots consisted four level of Nano iron fertilizer (F_0: Nonuse of Nano iron fertilizer or control, F_1: 0.002 $L.ha^{-1}$, F_2: 0.004 $L.ha^{-1}$ and F_3: 0.006 $L.ha^{-1}$ Nano iron fertilizer) was used at 3 to 4 leaves.

3.2. Farm Management

Each sub plot included the 6 planting lines with a length of 5 m. The distance between row and seed on the row were 75 and 18 cm respectively. Irrigation was done every 3 or 4 days and after the plant establishment it was done every 7 to 10 days if necessary. The weeds were controlled via Cruise herbicide by 2 $L.ha^{-1}$ at 4-to-5-leaf stage and Krakrown pesticide by 1 $L.ha^{-1}$ against leaf and stem borer larvae.

3.3. Measured Traits

The final harvest area of each plot was 1.5 m^2. Seed yield, its components and qualitative traits were estimated after the physiological maturity. After separating seed from selected plants and weighing them, seed yield was calculated based on 14% moisture. In order to estimate 100 seed weigh, 10 samples of seed containing 10 seed were separated and the means was calculated. Chlorophyll index (spad number) was measured with a chlorophyll meter, model (Spad-502), with an average of 10 leaves equal to 10 plants per plot at the stage of emergence of male flowers. To measure stem diameter and plant height, five plants from each plot were measured by caliper and cloth meter from the soil surface to the end of the cluster and their average was recorded as plant diameter and height in the desired treatment. To measure the diameter and length of the ear, the average of five ears from each plot was measured with a caliper and ruler and their average was recorded as the diameter and length of ear in the desired treatment. To measure the baldness of the ear, it was measured randomly using a ruler with an accuracy of 1 mm in five ears and then its mean was recorded as the bald length.

3.4. Statistical Analysis

ANOVA and mean comparisons were done via MSTAT-C software and Duncan test at 5% probability level.

4. RESULT AND DISCUSSION

4.1. Seed yield

Result of analysis of variance showed effect of different level of vermicompost and Nano iron fertilizer on seed yield was significant at 1% probability level but interaction effect of treatments was significant at 5% probability level (Table 1). Mean comparison of different level of vermicompost indicated that maximum seed yield (490.9 $gr.m^{-2}$) was noted for 10 $t.ha^{-1}$ vermicompost and minimum of that (214.5 $gr.m^{-2}$) belonged to control treatment (Table 2). As for Duncan classification made with respect to different level of Nano iron fertilizer maximum and minimum amount of seed yield belonged to 0.006 $L.ha^{-1}$ (419.1 $gr.m^{-2}$) and control (277.2 $gr.m^{-2}$) (Table 2). Evaluation mean comparison interaction effect of treatments indicated maximum seed yield (545.7 $gr.m^{-2}$) was for 10 $t.ha^{-1}$ vermicompost and 0.006 $L.ha^{-1}$ Nano iron fertilizer and lowest one (189.1 $gr.m^{-2}$) for control treatment (Table 3).

Table 1. Result analysis of variance of vermicompost and iron nano fertilizer on measured traits

S.O.V.	df	Seed yield	Plant height	Stem diameter	Ear length	Ear diameter	Ear loss length	Chlorophyll index
Replication	2	348.857^{ns}	179.602^{ns}	2.327^{ns}	2.984^{ns}	35.152^{ns}	0.755^{ns}	0.116^{ns}
Vermicompost (V)	2	229766.563**	3971.593*	214.322*	279.989*	194.692*	19.070*	1.642*
Error I	4	1085.941	236.405	4.213	8.756	25.497	0.092	0.125
Iron Nano Fertilizer (I)	3	32518.706**	1876.655*	82.617*	97.077*	144.297*	1.672*	0.457*
V×I	6	1961.823*	921.790*	69.710*	88.128*	86.857*	0.354^{ns}	0.194*
Error II	18	546.401	24.009	3.528	5.557	25.556	0.398	0.068
CV (%)	-	6.71	7.55	10.70	11.52	10.10	28.97	13.29

$^{ns, *}$ and **: no significant, significant at 5% and 1% of probability level, respectively.

Considering the importance of chlorophyll in production and the direct relationship between this trait and seed yield, researchers believe that increasing the amount of organic fertilizers and vermicompost in the soil leads to an increase in nutrients such as nitrogen, iron and magnesium, so mentioned nutrient have important role for chlorophyll production, more availability of nutrient for sink (seeds) and improve crop production. The effect of vermicompost from 0 to 10 tons per hectare on seed yield of corn showed that seed yield increased significantly showed the positive effect vermicompost on crop production because of stored assimilates (Amyanpoori *et al*., 2015). The most important effect of iron application is increasing in the rate of photosynthesis and improving the leaf area index, which results in increased seed yield compared with non-iron application conditions (Singh, 2000). Bybordi and Mamedov (2010) reported iron Nano fertilizer application on canola led to improve seed yield. Also Nazari *et al*. (2006) reported consume organic fertilizer led to increase corn yield, which consisted result of current research.

4.2. Plant height

According result of analysis of variance effect of different level of vermicompost, Nano iron fertilizer and interaction effect of treatments on plant height was significant at 5% probability level (Table 1). Result of mean comparison revealed maximum of plant height (228.4 cm) was obtained for 10 t.ha^{-1} vermicompost and minimum of that (195.8 cm) was for control treatment (Table 2). Evaluation mean comparison result indicated in different level of Nano iron fertilizer the maximum plant height (226.7 cm) was noted for 0.006 L.ha^{-1} and minimum of that (191.8 cm) belonged to control treatment (Table 2). Assessment mean comparison result of interaction effect of treatments indicated maximum plant height (273.6 cm) was noted for 10 t.ha^{-1} vermicompost and 0.006 L.ha^{-1} Nano iron fertilizer and lowest one (190.6 cm) belonged to control treatment (Table 3).

Table 2. Mean comparison effect of vermicompost and iron nano fertilizer on studied traits

Vermicompost ($t.ha^{-1}$)	Seed yield ($gr.m^{-2}$)	Plant height (cm)	Stem diameter (mm)	Ear length (cm)	Ear diameter (mm)	Ear loss length (mm)	Chlorophyll index (Spad)
0	214.5c	195.8c	14.23c	16.09c	46.34b	3.358a	1.603b
5	340.3b	198.2b	16.11b	19.64b	49.46ab	2.325b	1.954ab
10	490.9a	228.4a	22.31a	25.65a	54.33a	0.990c	2.343a
Iron nano fertilizer ($L.ha^{-1}$)							
0	277.2d	191.8b	14.64c	17.38c	45.76b	2.556a	1.691b
0.002	329.3c	204.6ab	16.62b	19.18bc	49.32ab	2.467ab	1.931ab
0.004	368.7b	206.7ab	17.13b	20.20b	49.67ab	2.078ab	2.007ab
0.006	419.1a	226.7a	21.80a	25.06a	55.43a	1.611b	2.238a

*****Similar letters in each column show non-significant difference at 5% probability level in Duncan test.

Comparing the growth of corn grown in soils containing different compost values showed that plants with more compost content in their soil had a biomass and, consequently, more yield than the others (Paino *et al.*, 1996). Safyan *et al*. (2011) stated that consumption of micro-nutritive element of iron has caused to increase plant height of maize.

4.3. Stem diameter

Result of analysis of variance showed effect of different level of vermicompost, Nano iron fertilizer and interaction effect of treatments on stem diameter was significant at 5% probability level (Table 1). Assessment mean comparison result indicated in different level of vermicompost the maximum stem diameter (22.31 mm) was noted for 10 $t.ha^{-1}$ and minimum of that (14.23 mm) belonged to control treatment (Table 2). Compare different level of Nano iron fertilizer showed that the maximum and the minimum amount of stem diameter belonged to 0.006 $L.ha^{-1}$ (21.80 mm) and control (14.64 mm) treatments (Table 2). Evaluation mean comparison result of interaction effect of treatments indicated maximum stem diameter (22.67 mm) was noted for 10 $t.ha^{-1}$ vermicompost and 0.006 $L.ha^{-1}$ Nano iron fertilizer and lowest one (13.10 mm) belonged to control treatment (Table 3).

4.4. Ear length

Result of analysis of variance showed effect of different level of vermicompost, Nano iron fertilizer and interaction effect of treatments on ear length was significant at 5% probability level (Table 1). Mean comparison result of different level of vermicompost indicated that maximum ear length (25.65 cm) was noted for 10 $t.ha^{-1}$ vermicompost and minimum of that (16.09 cm) belonged to control treatment (Table 2). As for Duncan classification made with respect to different level of Nano iron fertilizer maximum and minimum amount of ear length belonged to 0.006 $L.ha^{-1}$ (25.06 cm) and control (17.38 cm) (Table 2).

Table 3. Mean comparison of interaction effect of vermicompost and iron nano fertilizer on studied traits

Vermicompost ($t.ha^{-1}$)	Iron nano fertilizer ($L.ha^{-1}$)	Seed yield ($gr.m^{-2}$)	Plant height (cm)	Stem diameter (mm)	Ear length (cm)	Ear diameter (mm)	Chlorophyll index (Spad)
0	**0**	189.1d	190.6c	13.10d	11.75c	38.40c	1.117c
	0.002	244.7c	195.9bc	13.90cd	17.03bc	48.77b	1.757b
	0.004	248.0bc	196.3bc	14.27c	17.93bc	49.10b	1.832b
	0.006	256.7bc	198.2bc	15.47bc	17.65bc	49.10b	1.707b
5	**0**	257.5bc	195.5bc	14.20c	18.63b	49.27b	1.867b
	0.002	263.6bc	204.4b	16.53bc	19.27b	49.27b	1.913b
	0.004	272.8bc	208.6b	17.43bc	19.84b	49.67b	1.979b
	0.006	285.2bc	208.3b	18.27bc	20.81b	49.63b	2.056b
10	**0**	288.3bc	211.5b	18.43bc	21.78b	49.60b	2.091b
	0.002	296.3bc	213.4b	19.43b	21.26b	49.93b	2.121b
	0.004	308.0b	215.1b	19.70b	22.81b	50.23b	2.208b
	0.006	545.7a	273.6a	22.67a	26.73a	67.57a	2.951a

*****Similar letters in each column show non-significant difference at 5% probability level in Duncan test.

Evaluation mean comparison result of interaction effect of treatments indicated maximum ear length (26.73 cm) was noted for 10 $t.ha^{-1}$ vermicompost and 0.006 $L.ha^{-1}$ Nano iron fertilizer and lowest one (11.75 cm) belonged to control treatment (Table 3). Aram *et al*. (2009) stated that increasing animal manure by 60 tons per hectare increases the dry matter weight of corn.

4.5. Ear diameter

Result of analysis of variance showed effect of different level of vermicompost, Nano iron fertilizer and interaction effect of treatments on ear diameter was significant at 5% probability level (Table 1). According result of mean comparison maximum of ear diameter (54.33 mm) was obtained for 10 $t.ha^{-1}$ vermicompost and minimum of that (46.34 mm) was for control treatment (Table 2). Evaluation mean comparison result indicated in different level of Nano iron fertilizer the maximum ear diameter (55.43 mm) was noted for 0.006 $L.ha^{-1}$ and minimum of that (45.76 mm) belonged to control treatment (Table 2). Assessment mean comparison result of interaction effect of treatments indicated maximum ear diameter (38.40 mm) was noted for 10 $t.ha^{-1}$ vermicompost and 0.006 $L.ha^{-1}$ Nano iron fertilizer and lowest one (67.57 mm) belonged to control treatment (Table 3). Roknil (2013) concluded that the rapid increase in dry matter begins with an increase in leaf area and peaks when the plant reaches a maximum leaf area.

4.6. Ear loss length

According result of analysis of variance effect of different level of vermicompost and Nano iron fertilizer on ear loss length was significant at 5% probability level but interaction effect of treatments was not significant (Table 1). Mean comparison result of different level of vermicompost indicated that maximum ear loss length (0.990 mm) was noted for 10 $t.ha^{-1}$ vermicompost and minimum of that (3.358 mm) belonged to control treatment (Table 2).

As for Duncan classification made with respect to different level of Nano iron fertilizer maximum and minimum amount of ear loss length belonged to 0.006 L.ha^{-1} (1.611 mm) and control (2.556 mm) (Table 2).

4.7. Chlorophyll index

Result of analysis of variance showed effect of different level of vermicompost, Nano iron fertilizer and interaction effect of treatments on chlorophyll index was significant at 5% probability level (Table 1). According result of mean comparison the maximum amount of chlorophyll index (2.343 spad) was obtained for 10 t.ha^{-1} vermicompost and minimum of that (1.603 spad) was for control treatment (Table 2). Evaluation mean comparison result indicated in different level of Nano iron fertilizer the maximum chlorophyll index (2.238 spad) was noted for 0.006 L.ha^{-1} and minimum of that (1.691 spad) belonged to control treatment (Table 2). Assessment mean comparison result of interaction effect of treatments indicated maximum chlorophyll index (2.951 spad) was noted for 10 t.ha^{-1} vermicompost and 0.006 L.ha^{-1} Nano iron fertilizer and lowest one (1.117 spad) belonged to control treatment (Table 3). With the simultaneous consumption of vermicompost, the value of chlorophyll a and b increased. Using biological materials significantly increased indicators of growth and chlorophylls a and b (Sharifi *et al*. 2011). It has been demonstrated that iron has a great role in synthesis of chlorophyll, photosynthesis improvement and plant growth regulation (Jin *et al.*, 2008). Amanullah *et al.*, (2012) showed that spraying of iron sulfate increased chlorophyll concentration of corn leaf.

5. CONCLUSION

Use 10 t.ha^{-1} vermicompost with 0.006 L.ha^{-1} iron Nano fertilizer led to produce the highest amount of crop production, morphological traits and chlorophyll content and can be advice to farmers.

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FOOTNOTES

AUTHORS' CONTRIBUTION: All authors are equally involved.

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