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Evaluation Effect of Vermicompost and Nano Iron on Agro-Physiological Traits of Corn (*Zea mays* L.)

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RESEARCH ARTICLE

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ABSTRACT

In order to investigate the effect of vermicompost and Nano Iron on yield and yield components of maize, a farm experiment was done in a factorial based on completely randomized blocks design with three repetitions in Damavand in 2013. The first factor was vermicompost in two levels included no applying and applying (vermicompost 1 $kg.m^{-2}$) and the second factor was Nano iron fertilizer with four levels included no application (control), seed coated application, foliar application and both seed coated and foliar application. The result showed that all traits significantly affected by Vermicompost and Nano iron. Meaning comparisons showed that application of vermicompost caused to reach the best result for nearly all investigated traits than control. Applying Nano iron significantly increased stem height, dry weight, total chlorophyll, yield, biological yield and harvest index. Nano iron application in a form of seed coated and foliar application was better than the other levels. Finally it's suggested that to reach the best results should be applied of vermicompost and Nano iron in a form of seed coated and foliar application.

Keywords: *Chlorophyll, Dry matter, Maize, Yield.*

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INTRODUCTION

Maize is considered as one of the most important strategic and highly expected grains throughout the world. In order to have high quantitative and qualitative yield, maize must have an appropriate combination of nutrients (Malakouti and Gheibi, 2005). Maize is called King of cereals because of its productivity potential compared to any other cereal crop. Being an exhaustive crop, it has very high nutrient requirement and its productivity is closely depends on nutrient management system (Jaliya *et al.,* 2008). Maize has immense potential in the tropics and its yield reached up to7.5 $t.ha^{-1}$ if the crop is properly managed (Law-Ogbomo and Law- Ogbomo, 2009). But unfortunately still crop yields are below 5 $t.ha^{-1}$ (FAO, 2012) and it caused inadequacy of maize for its numerous usages. Yield differences between temperate and tropical areas have been attributed to low nutrient status especially these soils are deficient to nitrogen, phosphorus and potassium. Resulting of slash and burn farming system associated with bush fallow and excessive leaching of the soil nutrients (Law-Ogbomo and Law-Ogbomo, 2009) are presently unsustainable due to high population pressure and other human activities which have resulted in reduced fallow period (Steiner, 1991). Various factors affected the productivity of winter maize; however, the fertilizer management is one of the most important factors that affect the growth and yield of maize (Anonymous, 1979). Low fertility status of tropical soils hindered maize production as maize has a strong exhausting effect on the soil. It was generally observed that maize fail to produce good seed without adequate nutrients (Adediran and Banjoko, 2003). Inorganic fertilizer exerts strong influence on plant growth, development and yield of maize crop (Predieri *et al*., 2004). Availability of sufficient nutrients leads to improve cell activities, cell multiplication and enlargement and luxuriant growth (Fashina *et al.,* 2002). Luxuriant growth resulting from fertilizer application leads to larger dry matter production (Obi *et al.,* 2005) owing better utilization of solar radiation and more nutrient (Saeed *et al.,* 2001). Furthermore, substantial depletion of nutrients increased with the cultivation where no NPK fertilizer was applied Adediran and Banjoko (2003). Vermi composting technology involves the bio-conversion of organic waste into vermicasts and vermiwash utilizing earthworms (Jadia and Fulekar, 2008). These earthworms feed on the waste and their gut act as the bioreactor where the vermicasts are produced (Ansari and Sukhraj, 2010). These vermicasts are also termed vermicompost and are rich in nitrogen, phosphorous, potassium and micronutrients (Ansari and Sukhraj, 2010; Palanichamy *et al.,* 2011). Effect of these vermicompost on plant growth is well reported but mostly it used as a main source of nitrogen. Increasing the vermicompost quantity also promoted plant growth as well as growth of the cob webs by increasing the zinc and phosphorous like nutrients. Zinc enhances plant growth regulation whilst phosphorous promotes plant growth (Abbasi *et al.,* 2009; Manyuchi *et al*., 2013a; Manyuchi *et al.,* 2013b). Increasing the level of phosphorous content in the soils also promoted plant growth, high resistance and quality of seed. Furthermore, it was well documented that increasing the application time of both the vermicompost and vermiwash also increased the soil copper, iron and phosphorous content (Manyuchi *et al*., 2013c; Nath and Singh, 2012). This increase in soil nutrient content promoted plant growth and chlorophyll production; hence boost the overall corn growth. In addition, microbial activities was also reported higher in the soil treated by vermicompost and this higher microbial activity also affected the production of plant growth regulators such as cytokinins as well as humic acid which promote plant growth (Gopal *et al.,* 2010; Manyuchi *et al.,* 2013d). The effect of vermicompost on plant growth is significant and increases the growth potential, yield and yield components of different plants (Atiyeh *et al.,* 2000). Vermicompost, along with chemical fertilizers, improves the usefulness of low-energy elements and their absorption in plants compared with the use of chemical fertilizers alone (Jibin and Ahmad, 2017). Iron deficiency is widespread and is one of the most concerned to healthcare officials among almost all developing countries (Buyckx, 1993). 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 nanoscale 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 nanoparticles 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. 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. The objective of this study was to determine the effect of vermicompost and Nano Iron on yield and yield components of maize in Damavand region.

MATERIALS AND METHODS

Field and Treatment Information

In order to investigate effect of vermicompost and Nano iron on yield and some important traits of maize, a farm experiment was done in a factorial based on completely randomized blocks design in three repetitions in Damavand region in 2013. The first factor was vermicompost in two levels included no applying and applying (1 kg vermicompost in m^2) and the second factor was Nano iron fertilizer with four levels included no application (Control), seed coated application, foliar application and both seed coated and foliar application. Soils were fertilized according to recommendation based on soil tests (Table 1) and the level of treatments.

Table 1. Physical and chemical properties of the studied field

Soil depth (cm)	0-30	30-60
pH	8.41	8.62
EC ($ds.m^{-1}$)	3.66	2.09
O.C (%)	1.55	0.98
Phosphorus (ppm)	9.01	9.55
Potassium (ppm)	169	162
Clay (%)	22	21
Silt (%)	44	42
Sand (%)	34	33

Farm Management

The field was plowed, fertilized, and leveled before the field maize planted. The size of each treatment was 6×5 m². Phosphorus and potassium fertilizers were provided from 150 $kg.ha^{-1}$ triple super phosphate and 150 $kg.ha^{-1}$ potassium sulfate. Biological fertilizer of nitroxin was used as much as two $L.ha^{-1}$ as combined with seeds. Nitrogen chemical fertilizer was provided from the urea source, 50% during planting and 50% during 8-leaf stage. Irrigation was done every 3 or 4 days and after the plant establishment it was done every 7 to 10 days if necessary. Weeds were controlled via Cruise herbicide by two $L.ha^{-1}$ at 4-to-5-leaf stage and Krakrown pesticide by one $L.ha^{-1}$ against leaf and stem borer larvae.

Traits Measure

Total dry matter, seed yield and its components were estimated after the physiological maturity by harvesting interior rows (the outer rows excluding at least 0.5 m from either end of the rows. The samples were for 48 hours in the oven at 72-75 ^{0}C and dry weight was measured. To calculate the number of seeds per row and number of row per ear, of each plot, 10 ears was selected randomly and number of seeds per row , number of rows per ear were counted, and average 10 ear were considered as the number of seeds per ear and number of rows per ear for that plots. Harvest index is calculated as the ratio of seed yield to dry matter yield. To measure Chlorophyll index of leaves, from 3 points of leaf measured chlorophyll with SPAD 502 device and the average of 3 numbers was considered.

Statistical analysis

The analysis of variance was done by SAS software (Ver 8.1) and the means were compared using Duncan's multi range test at 5% probability level.

RESULTS AND DISCUSSION

Plant height

The results of ANOVA showed that the effect of vermicompost and Nano iron on plant height was significant at 1% probability level (Table 2). The results of means comparison showed that the compost increased the stem height from 1 to 2448.5 cm and the incidence of consumption was up to 200 cm high (Table 3).

Table 2. Analysis of variance of studied traits

S.O.V.	df	Plant height	Dry weight	Chlorophyll	Seed yield	Biological yield	Harvest index
Block	2	717.13^{ns}	550.45^{ns}	0.004 ^{ns}	2.29 ^{ns}	0.1 ^{ns}	0.007 ^{ns}
Vermicompost (V)	1	13598**	23515.7**	4.01**	29.08**	119.03*	0.03*
Nano Iron (NI)	3	6875**	2786.8**	1.9**	13.34**	62.09*	0.028**
V*NI	3	2147^{ns}	1873.4^{ns}	1.14^{ns}	6.5^{ns}	8.6^{ns}	0.006^{ns}
Error	14	610.69	542.5	0.11	1.18	17.78	0.005
C.V (%)	-	5.5	4.2	6.6	1.5	4.8	8.8

ns, * and **: non-Significant, significant at the 0.05 and 0.01 probability level, respectively.

Comparing the growth of corn grown in soils containing different compost values showed that plants with more compost content in their soil had a bio-mass and, consequently, more yield than the others (Paino *et al.,* 1996). The results of means comparison showed that cropping along with nano iron spraying increased the height of corn of 253 cm and the lowest amount (172.20 cm) was observed in non use of nano iron (Table 4). Safyan *et al.* (2011) stated that consumption of micro-nutritive element of iron has caused to increase plant height of maize.

Chlorophyll

The results of analysis of variance showed that the effect of vermicompost and Nano iron on total chlorophyll was significant at 1% probability level (Table 2). The results of mean comparisons showed that vermicompost consumption cause to increase the total chlorophyll of the plant .The highest total chlorophyll was 2.4 mg.g^{-1} fw with vermicompost consumption and the lowest biological yield (0.5 mg.g^{-1} fw) was not used (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). The highest total chlorophyll was (3.6 mg.g^{-1} fw) related to Nano-iron application as both seed coated and foliar application and the lowest was (0.3 mg.g^{-1} fw) with out application of Nano-iron (Table 4). 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.

Dry weight

The results of analysis of variance showed that the effect of vermicompost and Nano iron on dry weight was significant at 1% probability level (Table 2). The results of mean comparisons showed that vermicompost consumption increased the dry weight of the plant by 252.83 grams and no consumption was 182.97 grams (Table 3). The effect of vermicompost on growth of evergreen flowers reported that vermicompost cause to increase dry weight of plants. Edwards and Bates (1992) found that earthworms increased significantly the number, growth rate, and yield of plants growing on inoculated sites. The highest seed yield was 78.32 grams related to Nano-iron application as both seed coated and foliar application and the lowest was 54.25 grams with out application of Nano-iron (Table 4). Iron is an essential for growth in plants and plays an important role in the activity of enzymes and photosynthesis. The activity of this fertilizer increases the dry weight of the whole plant (Hamouda *et al.,* 2011).

Table 3. Mean comparison effect of vermicompost on studied traits

Treatments	Plant height (cm)	Dry weight (g)	Chlorophyll ($mg.g^{-1}$ fw)	Seed yield ($t.ha^{-1}$)	Biological yield ($t.ha^{-1}$)	Harvest index (%)
No application	200.90^{b}	24.30^{b}	0.5^{b}	2.9^{b}	14.62^{b}	20^{b}
Application	248.50^{a}	89.10^{a}	2.4^{a}	7.5^{a}	19.07^{a}	41^{a}

*Means followed by similar letters have not significantly different ($p<0.05$) via Duncan test.

Spraying of coriander with zinc and iron at vegetative, flowering stage and fruit formation significantly increased fresh and dry weight of stem and seed yield and the combined application of iron+zinc played a more significant role (Said Al-Ahel and Omar, 2009).

Seed yield

The results of ANOVA showed that effect of vermicompost and Nano iron on seed yield was significant at 1% probability level (Table 2). The results of mean comparisons showed that vermicompost consumption increased seed yield of the plant up to 7.5 $t.ha^{-1}$ and no consumption of vermicompost cause to decrease seed yield of corn down to 2.9 $t.ha^{-1}$ (Table 3). Using vermicompost, the physical and chemical properties of the soil have improved, resulting in more root development, reducing water losses, and conditions for improved growth and photosynthesis, and thus plant will be able to produce more biomass and biological yield (Sainz *et al.,* 1998). Singh *et al*. (2012) reported vermicompost increased chickpea yield. Seghatoleslami (2013) on cumin also reported that manure application increases cumin yield. The highest seed yield was 6.9 $t.ha^{-1}$ related to Nano-iron application as both seed coated and foliar application and the lowest was 3.6 $t.ha^{-1}$ with out application of Nano-iron (Table 4). To study effect of irrigation time of iron Nano fertilizer in stemming stage, best results were achieved with 99% increase in yield and an increase of 32.4% in iron content and increase of quantitative and qualitative traits was more than control.

Biological yield

The results of ANOVA showed that the effect of vermicompost and Nano-iron effect on biological yield was significant at 5% probability level (Table 2). The results of comparison of means showed that the highest biological yield was 19.08 $t.ha^{-1}$ with vermicompost consumption and the lowest biological yield (14.63 $t.ha^{-1}$) was not used (Table 3). Manure application improves the soil structure and soil moisture content, provides plant with essential elements, increases growth, number of umbrella per plant and biological yield and finally led to increase seed yield (Ahmadian *et al.,* 2011). Several studies have investigated the positive effect of vermicompost on increasing the quantitative and qualitative performance of crops and medicinal plants, including the effect of vermicompost on biological yield, basil, chamomile, forage corn, forage forage, forage sorghum, artemisia and Joe pointed out (Haj Seyed Hadi *et al.,* 2010). The highest biological yield was 19.67 $t.ha^{-1}$ related to Nano-iron application as both seed coated and foliar application and the lowest was 12.27 $t.ha^{-1}$ with out application of Nano-iron (Table 4).

Harvest index

The results of ANOVA showed effect of vermicompost and nano iron on on harvest index was significant at 5% and 1% probability level respectively (Table 2). According results of means comparison harvest index with consumption of vermicompost was 39% and without consumption Vermicompost was 15.2% (Table 3).

Table 4. Mean comparison effect of Nano Iron on studied traits

Treatments	Plant height (cm)	Dry weight (g)	Chlorophyll ($mg.g^{-1}$ fw)	Seed yield ($t.ha^{-1}$)	Biological yield ($t.ha^{-1}$)	Harvest index (%)
No application	176.2^{c}	54.24^{c}	0.3^{d}	3.6^{c}	12.27^{c}	26^{c}
Seed coated	240.24^{b}	70.78^{b}	2.3^{c}	5.2^{b}	17.2^{b}	30^{b}
Foliar application	229.36^{b}	75.14^{ab}	3.4^{ab}	6.2^{a}	19.67^{ab}	34^{ab}
Seed coated and foliar application	253.37^{a}	78.32^{a}	3.8^{a}	6.9^{a}	20.2^{a}	36^{a}

*Means followed by similar letters have not significantly different ($p<0.05$) via Duncan test.

The experimental results showed that the use of vermicompost in corn increased the harvest index. (Mojab Qasr al-Dashti *et al*., 2011). The highest harvest index related to Nano-iron application as both seed coated and foliar application (36%) and the lowest was 26% with out application of Nano-iron (Table 4). Zhang *et al*. (2008) reported that application of iron fertilizer could have a positive effect on rice harvest index.

CONCLUSION

Applying Nano iron significantly increased stem height, dry weight, total chlorophyll, yield, biological yield and harvest index. Use Nano iron in a form of seed coated and foliar application was better than the other levels. Finally it's suggested that to reach the best results should be applied of vermicompost and Nano iron in a form of seed coated and foliar application.

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