Running title: Effect of Organic and Inorganic Fertilizers on Wheat

**The Effect of Nitrogen+ Sugarcane Residue Compost and Nitroxin on Yield of Wheat**

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**Novelty statement**

The results revealed that, compared to that without compost, less nitrogen fertilizer is needed to achieve a higher maximum wheat yield after combining the fertilizer with compost. Also, the conjunctive use of sugarcane residue compost and mineral fertilizers was shown a worthwhile approach to improve crop productivity. Hence sugarcane residue compost, make it possible a cut down of mineral fertilizer doses reflecting in higher yields of wheat and better environmental sustainability.

**Abstract**

In order to evaluate the effect of nitrogen+ sugarcane residue compost and nitroxin on growth and yield of wheat in Ahwaz, an experiment was conducted in research farm of Agricultural Sciences and Natural Resources University of Khuzestan, Ahwaz, Iran during 2019-2020 growing season as split plot arrangement based on randomized complete block design with three replications. Experimental factors included different compounds of nitrogen fertilizer+ sugarcane residue compost (A1: 100% chemical fertilizer (150 kg/ha)), A2: 75% chemical fertilizer (112.5 kg/ha)+ 25% compost (7.5 ton/ha), A3: 50% chemical fertilizer (75 kg/ha)+ 50% compost (15 ton/ha), A4: 25% chemical fertilizer (37.5 kg/ha)+ 75 % compost (22.5 ton/ha), A5: 100% compost (30 ton/ha)) in main plots and two levels of nitroxin (control and application) in sub plots. The analysis of variance showed that the effect of nitrogen fertilizer+ sugarcane residue compost and nitroxin were significant on the traits of plant height, spike length, spike number per m2, grain per spike, thousand grain weight, grain yield, biological yield and harvest index. But, the interaction effect of nitrogen fertilizer+ sugarcane residue compost and nitroxin was not significant. The mean comparison of traits in nitrogen fertilizer+ sugarcane residue compost showed that the maximum grain yield (4313 kg/ha) was in A3: 50% chemical fertilizer (75 kg/ha)+ 50% compost (15 ton/ha), and the minimum grain yield (1780 kg/ha) was in A5: 0% chemical fertilizer (0 kg/ha)+ 100% compost (30 ton/ha). The mean comparison of measured traits by nitroxin application showed that grain yield in the absence of nitroxin application was 2568 kg/ha and increased with nitroxin application and reached 3750 kg/ha. Generally, the results of this experiment indicated that using chemical and organic fertilizer with nitroxin because of nutrient elements availability and water reserving, increased growth, yield components and grain yield of wheat. So, using chemical and organic fertilizer with nitroxin could be recommended for increasing growth and grain yield of wheat in Ahwaz region.

**Keywords**: Chemical fertilizer, organic fertilizer, biological fertilizer, plant nutrition, Khuzestan.

**Introduction**

Wheat is the most important cereal crop in the world and is the first staple food crop in Iran (Moshatati *et al*. 2017). The harvested area and the total production of wheat in the world was 214 million ha and 734 million ton, respectively (FAO 2019). During 2017-2018 growing season, about 5.8 million ha land was allocated to wheat and the total production reached to 13.7 million ton in Iran (MAJ 2019).

Wheat yield is affected by many factors, including genotype, weather, soil properties, and agronomic management. Nitrogen is the most important nutrient for wheat production that affects growth, yield and quality of wheat (Mandic *et al*. 2015). Availability of nitrogen has impacts throughout wheat development, affecting seedling establishment, tillering, canopy development as well as grain filling, all of which have the potential to influence final yield and together determine the nitrogen requirements of the wheat (Hawkesford 2014). It is widely recognized that chemical fertilizers have made a significant contribution to the continuous increase in agricultural food production in the past decades (Jiang et al. 2020). Also, chemical fertilizers are an important input to get higher crop productivity and are more economical, affordable, easy to use and quick in response (Chattah *et al*. 2019). Soils in Khuzestan province are low in organic matter content, which corresponds to low soil fertility and poor soil structure. Also, large amounts of chemical fertilizers are usually applied to farmlands to ensure high wheat yield in Khuzestan. However, excess and continued use of chemical fertilizer (especially nitrogen) by local farmers can cause environmental resources pollution such as ground and surface water pollution by nitrate leaching, and low soil fertility (Rana *et al*. 2012; Jiang *et al*. 2020).

As excess use of chemical fertilizer alone has resulted in numerous negative effects, it is necessary to limit the application of chemical fertilizer and find the suitable method to maintain grain yield and soil fertility (Guo *et al*. 2016). One of the possible options to reduce the use of chemical fertilizer could be using organic fertilizer such as compost (Abedi *et al*. 2010). Using compost as a substitute for chemical fertilizer has been regarded as an effective strategy to maintain soil fertility and promote sustainable crop production (Zhao *et al*. 2009). Several studies have reported that combined use of organic manures and inorganic fertilizers can improve soil fertility and water holding and supply essential nutrients to the crops leading to increased growth, grain yield and biomass of wheat and reduced environmental pollution than using chemical fertilizers alone (Rehman *et al*. 2008; Abedi *et al*. 2010; Guo *et al*. 2016; Subhan *et al*. 2017; Chen *et al*. 2018; Chattah *et al*. 2019; Hammad *et al*. 2020; Yang *et al*. 2020). However, an unreasonable combination ratio of manure-N and inorganic-N does not result in high yields, but it instead caused a large amount of soil nitrate-N residue accumulation, which migrates down to deeper soil and causes pollution in the underground water (Jiang *et al*. 2020). Compost is an important source of nutrients elements especially nitrogen, phosphorus and potassium (Abedi *et al*. 2010). Also, compost has greater organic matter content and improves physico- chemical attributes, fertility and water holding capacity of soil and it ultimately results in increased yield of crop (Subhan *et al*. 2017). Sugarcane residues compost is a by-product of sugarcane industry that occupies a special position among organic nutrient sources and the application of sugarcane residues compost improves soil fertility, water holding capacity and organic matter (Chattah *et al*. 2019). Many studies showed that the application of compost to soil have increased soil organic matter, soil fertility, soil water-holding and crop yield (Guo *et al*. 2016; Hammad *et al*. 2020; Yang *et al*. 2020). For example, Abbasi and Tahir (2012) found that replacing 25% chemical N fertilizer with organic manure could ensure stable wheat yields. Xin et al. (2017) illustrated through a recent meta-analysis that substituting organic manure for chemical fertilizer increased crop productivity by 7%. Also, Yang *et al*. (2020) concluded that mixing organic and inorganic nitrogen fertilizer significantly increased the grain yield of wheat.

In sustainable agriculture, supplementation with bio-fertilizers is a suitable and environmentally friendly alternative for enhancing crop yields, to sustain the inherent fertility of soils (Rana *et al*. 2012). Also, it is a widely accepted practice to enhance sustainable agricultural production by inoculating soils and crops with plant growth-promoting rhizobacteria (PGPR) (Wang *et al*. 2020). Plant growth-promoting rhizobacteria (PGPR) are a group of free-living bacteria that can enhance plant growth and crop yield through several mechanisms. PGPR comprise different functional and taxonomic groups of bacteria like *Pseudomonas, Bacillus, Rhizobium* and others (De Benedetto *et al*. 2017). PGPR can produce hormones that stimulate plant growth, make nutrients available, fix atmospheric nitrogen, act as bio-control agents, and improve soil structure (Sherdil *et al*. 2019). Nitroxin is a bio-fertilizer that contains *Azospirilium* and *Azotobacter* rhizobacteria. These rhizobacteria can stimulate plant growth through increasing nutrient uptake, nitrogen fixation, flavins, thiamine, antibiotic synthesis, antifungals, and phyto-hormones such as auxins, gibberellins, and cytokinins (Kamali and Mehraban 2020). Several studies reported that using plant growth-promoting rhizobacteria increased crop growth and yield (Rana *et al*. 2012; De Benedetto *et al*. 2017; Kamali and Mehraban 2020)

Despite the abundance of research on the effect of chemical fertilizer, compost and bio-fertilizers on wheat across the world, studies that explore this effect on wheat in Ahwaz remain scant. In an attempt to contribute to this research, an experiment was carried out to evaluate the effect of chemical fertilizer, compost and bio-fertilizers on growth and yield of wheat in research farm of Agricultural Sciences and Natural Resources University of Khuzestan, Ahwaz, Iran.

**Material and Methods**

**Experimental site**

The experiment was conducted at the research farm of Agricultural Sciences and Natural Resources University of Khuzestan situated in Ahwaz, South-West of Iran (31º 59′ N, 48º 88′ E and 34 m above the sea level) during 2019-2020 growing season.

Prior to planting, surface (0-30 cm) soil samples, from ten spots across the experimental field, were collected, composited and analyzed for soil physic-chemical properties at soil laboratory and results are presented in Table 1.

**Experimental design**

The experimental factors were arranged in split-plot arrangement based on a randomized complete block design (RCBD) with three replications. Experimental factors included five compounds of chemical nitrogen fertilizer and sugarcane residue compost (A1: 100% chemical nitrogen fertilizer (150 kg/ha)), A2: 75% chemical nitrogen fertilizer (112.5 kg/ha)+ 25% compost (7.5 t/ha), A3: 50% chemical nitrogen fertilizer (75 kg/ha)+ 50% compost (15 t/ha), A4: 25% chemical nitrogen fertilizer (37.5 kg/ha)+ 75% compost (22.5 t/ha), A5: 100% compost (30 t/ha)) as main plots and two levels of bio-fertilizer (control and application) as sub plots. The sugarcane residues compost obtained from Iran Fertilizer Company, Shooshtar, Iran and incorporated in the soil before sowing. The physic-chemical properties of compost were recorded in the beginning of the experiment (Table 1). Seeds were inoculated using nitroxin bio-fertilizer (which is a mixture of the most effective nitrogen fixing bacterial genus including *Azospirillum* and *Azotobacter*) produced by Mehr Asia Biotechnology Company, Tehran, Iran.

Plot size was 5 m2. The distance between the plots and blocks were kept at 0.5 m and 1.5 m apart, respectively. Each plot had 10 rows with 2.5 m length and 20 cm row spacing. The seeds of a locally widely used spring wheat cultivar ‘Chamran2’ were obtained from the Department of Agriculture, Ahwaz, Iran. The seeds were sown manually at plant density of 400 seeds/ m2 on 5 December 2019. The half on nitrogen fertilizers (from urea) and all the sugarcane residue compost were applied to plots as basal dose and incorporated into the top 0-20 cm soil layers before sowing in early December and the remaining half of nitrogen was used as top dressing at stem elongation stage. Weeds were controlled manually. At maturity stage, harvesting was done manually at ground level on 21 April 2020.

**Data collection**

At harvest, plant height and spike length, were measured from 20 random plant from each sub plot. The grain yield and biological yield at harvest maturity stage were determined after threshing the sun-dried plants harvested from 2 m2 of each plot, and the yield was adjusted at 14% moisture content. The spike number per m2 was recorded from the harvested area. The average number of grains per spike was calculated based on 20 spikes. The thousand grain weight was determined by counting the grains using an electronic seed counter. Harvest index was calculated as the ratio of grain yield to the total above ground biomass yield.

**Statistical analysis**

Analysis of variance (ANOVA) was performed using statistical analysis system (SAS version: 9.4). The significant of the treatment effect was determined using *F*-test. When ANOVA indicated that there was a significant value, comparisons of mean value were performed using the least significant difference method (LSD) at the 5% level of significance. Direct relationships between studied traits were analyzed with simple Pearson correlation coefficients.

**Results**

The analysis of variance showed that the main effect of different levels of chemical nitrogen fertilizer+ sugarcane residue compost and bio-fertilizer were significant at 1% probability level for all measured traits. While, there was no significant interaction between chemical nitrogen fertilizer+ sugarcane residue compost and bio-fertilizer for all studied traits (Table 2).

**Plant height**

The effect of inorganic fertilizer+ organic amendments and bio-fertilizer were significant on plant height of wheat (Table 2). Plant height varied from a minimum of 73.3 cm in A5 (100% compost) to a maximum of 90.2 cm in A3 (50% chemical+ 50% compost) treatment (Table 3).

The comparison between inoculated and un-inoculated plants showed that the inoculants significantly enhanced the plant height of wheat (Table 4).

**Spike length**

The application of chemical fertilizer combined with sugarcane residue compost at various rates had statistically significant effect on spike length (Table 2). In this study, the results showed that substitution with organic manure increased the spike length of wheat. So that, the spike length of wheat was significantly greater (9.2 cm) in A3 (50% chemical+ 50% compost) than other treatments. The least spike length (7.2 cm) was achieved from A5 (100% compost) treatment (Table 3). The seeds inoculated with bio-fertilizer caused a significant increase in the spike length, as compared to the control treatment (Table 4).

**Spike per m2**

Spike per m2 play a significant role in grain yield. Application of different combinations of chemical nitrogen fertilizer+ sugarcane residue compost was significantly affected the spike per m2 (Table 2). The highest spike per m2 (417.5) occurred in the plots fertilized with A3 (50% chemical+ 50% compost) and the lowest spike per m2 (253.1) occurred in the plots fertilized with A5 (100% compost) treatment (Table 3). The spike per m2 was better in inoculated treatments in comparison to the control (Table 4).

**Grain per spike**

The integrated nutritional levels had significant effect on the grain per spike (Table 2). The results revealed that the application of 50% chemical+ 50% compost (A3) produced the maximum number of grain per spike (37.5). The minimum number of grain per spike (26.8) was obtained from A5 (100% compost) treatment. (Table 3). The bio-fertilizer treatment increased the grain number per spike of wheat in comparison to the control treatment (Table 4).

**Thousand grain weight**

Various combinations of chemical nitrogen fertilizer+ sugarcane residue compost showed significant effect on the thousand grain weight (Table 2). Among combination of chemical nitrogen fertilizer+ sugarcane residue compost, the maximum thousand grain weight (38.8 g) was achieved in A3 (50% chemical+ 50% compost) treatment and the minimum thousand grain weight (35.2 g) was observed in A5 (100% compost) treatment (Table 3). In this study, plants inoculated with PGPR exhibited higher thousand grain weight (Table 4).

**Grain yield**

Grain yield of the wheat crop is the result of collective contribution of different yield components, which are significantly affected by availability of element nutrients. The analysis of variance showed that grain yield of wheat was affected by simple effects of chemical nitrogen fertilizer+ sugarcane residue compost and inoculation with bio-fertilizers at 1% level, while the interaction effect of these treatments on this trait was not significant (Table 2). According to the results of means comparison (Table 3), grain yield was significantly increased in A3 (50% chemical+ 50% compost) treatment. So that, the highest amount of this trait (4331 kg/ha) was obtained from A3 (50% chemical+ 50% compost) treatment. Also, the lowest amount of this trait (1780 kg/ha) was obtained from A5 (100% compost). The PGPR had a positive and significant effect on the wheat grain yield, so that the yield of the plants under the inoculated treatment increased by approximately 46%, as compared to the un-inoculated yield (Table 4).

**Biological yield**

Biomass is an important parameter to determine the photosynthetic activity and the yield of a crop. The results indicated that biological yield was significantly affected by various combinations of chemical nitrogen fertilizer+ sugarcane residue compost (Table 2). The biological yield was lowest (6923 kg/ha) in A5 (100% compost) and the highest biological yield (13403 kg/ha) was in A3 (50% chemical+ 50% compost) treatment (Table 3). The results indicated that the wheat seeds inoculated with bio-fertilizer exhibit a better biological yield, as compared to the control treatment (Table 4).

**Harvest Index**

Harvest Index is an important parameter describing the amount of grains received from total dry matter yield of a crop. Data regarding the harvest index showed the significant differences among the treatments (Table 2). This trait exhibited a modest variation, compared to grain yield and biological yield that are its two components. However, there was not significant differences between A1, A2, A3 and A4 treatments and A5 (100% compost) featured a statistically lower harvest index than the other treatments (Table 3). The harvest index of the inoculated plants was increased compared to that of the un-inoculated plants (Table 4).

**Correlation between measured traits**

Correlation coefficients were calculated in order to investigate the relationship among grain yield and yield components. Correlation coefficients between measured traits (Table 5) showed that grain yield had the strongest correlation with biological yield (0.94), spike per m2 (0.92) and grain per spike (0.90), suggesting that increase in biological yield, spike per m2 and grain per spike, would increase grain yield. The biological yield had the highest correlation with grain yield (0.94), grain per spike (0.90) and spike per m2 (0.89). Also, the harvest index had the lowest correlation with plant height (0.38) and biological yield (0.47), indicating that increase in plant height and biological yield, would decrease harvest index. These results are similar to those obtained by Mecha *et al*. (2017).

**Discussion**

The increased plant height under A3 (50% chemical+ 50% compost) treatment could be attributed to a higher nitrogen content and availability in the soil, an increased absorption of nitrogen, increased photosynthesis and greater cell division (Jiang et al. 2020). In agreement with the present experiment, plant height increases due to the integrated application of chemical and organic fertilizers have been reported by other researchers on wheat (Subhan *et al*. 2017; Chattha *et al*. 2019). The results presented here support the hypothesis that bio-fertilizer can improve the plant height of wheat. These bacteria directly affected the growth of the plants by increasing the nitrogen absorption, the synthesis of phyto-hormones and the dissolving of minerals (Akbari *et al*. 2011). Similar results due to the application of PGPRs have been reported previously in wheat. For example, an increase in the plant height of wheat plants due to the application of PGPRs was reported by Sherdil *et al*. (2019).

In spike length trait, access to more nitrogen in soil, the increase of absorption and more photosynthesis by plants are the factors that result in spike length increase in the integrated treatments. Previous studies have shown that organic and inorganic fertilizers can significantly increase the spike length of wheat (Subhan *et al*. 2017). Also, the highest spikes could have been attributed to the greater cell division due to increased availability of nutrients especially nitrogen. The role of plant growth promoting rhizobacteria (PGPR) in enhancing wheat growth has been investigated by previous studies (Wang *et al*. 2020).

These current results demonstrate that, using 50% chemical+ 50% compost (A3) allow reduced rates of chemical fertilizer. Thus, the increase in spikes per m2 was due to increased soil fertility under organic and inorganic fertilizer (Chattha *et al*. 2019). Similar results due to the integrated application of chemical and organic fertilizers have been reported previously in wheat (Hammad *et al*. 2020). The beneficial effects of this bio-fertilizer on spike per m2 was probably due to its contribution to plant growth by nitrogen fixation and the production of auxin and other phytohormones (Kamali and Mehraban 2020). This result agrees with Sherdil *et al*. (2019) who reported that the application of PGPRs increased the spike per m2 of wheat plants.

The application of chemical fertilizer with compost increased the grain number per spike due to the high activity of microorganisms, the ability of the plant to access more nitrogen in the soil and, possibly, higher nitrogen absorption and transfer of the nitrogen to the shoot, leading to an increase in the grain number per spike (Hammad *et al*. 2020). Previous studies have shown that organic and inorganic fertilizers can significantly increase the grain number per spike of wheat (Subhan *et al*. 2017). The increase in the grain number per spike in the bio-fertilizer treatments could be attributable to the exudation of plant growth regulators (PGRs), such as auxins and gibberellin by *Azospirillum*, and also the exudation of auxin, gibberellin and cytokinin by *Azotobacter* (Akbari *et al*. 2011). An increase in the grain number per spike of wheat plants due to the application of PGPRs was reported by Wang *et al*. (2020).

Favorable effect of organic and inorganic fertilizers on thousand grain weight may be due to the increased availability of plant nutrients, improvement of soil, water holding capacity and reduction of volatilization of nitrogenous fertilizers to NH3 gas. (Rehman *et al*. 2008). This agrees with Abedi *et al*. (2010) who reported that higher nitrogen rates with suitable amount of moisture extended the leaf area duration, duration of photosynthesis production during grain fill and finally increased thousand grain weight. The beneficial effects of this bio-fertilizer on thousand grain weight was probably due to its contribution to plant growth by nitrogen fixation and the production of auxin and other phyto-hormones (Kamali and Mehraban, 2020). The enhancement in thousand grain weight of wheat crop plants in response to inoculation with PGPR has been reported by Sherdil *et al*. (2019).

The integrated application of 50% chemical+ 50% compost increased grain yield by 34% relative to that of single inorganic fertilizer application. Thus, sugarcane residue compost needs to be integrated by nitrogen chemical fertilizers to secure unconstrained growth and final top yield. Especially the central combination (50% chemical+ 50% compost) was statistically better than 100% chemical in all yield traits. This demonstrates the role of sugarcane residue compost in enhancing plant growth and final yield. The lowest grain yield was achieved in A5 (100% compost) nutritional system, probably due to the fixation of mineral nitrogen by organic fertilizers, especially in the early growth stages of the plant, and also the long term and non-immediate effects of organic nutrients on crop yield. The release rate of available nitrogen from organic nitrogen is very slow, which was related to soil fertility, climatic conditions and other factors. Therefore, it usually fails to meet the nitrogen demand of crops in time, thus resulting in decreased yield (Yang *et al*. 2020). This increase in yield for the integrated nutritional levels might be due to a better compatibility between the soil available nitrogen and the requirements of the plant, indicating that the mineral nitrogen content of the organic nutritional level was less than that of the chemical fertilizer at the beginning of growth when the demand is low, but, at the reproductive growth stages, the absorption continues for a longer time because of the continuous mineralization process (Shoghi *et al*. 2013). Previous studies have reported that the combination of chemical fertilizer and compost increased wheat yield relative to applying inorganic fertilizer alone (Chen *et al*. 2018; Chattha *et al*. 2019). The beneficial effects of this bio-fertilizer on grain yield was probably due to its contribution to plant growth by nitrogen fixation, the dissolving of minerals and the production of plant growth regulators (PGRs), such as auxin and gibberellin by *Azospirillum*, and also the exudation of auxin, gibberellin and cytokinin by *Azotobacter* (Akbari *et al*. 2011; Kamali and Mehraban 2020). Wang *et al*. (2020) reported that inoculation of wheat with PGPR increased wheat yield. In another study, Sherdil *et al*. (2019) reported that the application of PGPR to wheat increased grain yields by 38%.

As compared to the organic and chemical levels, the observed increases in the biological yield at the A3 (50% chemical+ 50% compost) treatment may be attributed to the increases in the vegetative components (such as plant height and spike length) and reproductive components (spike per m2, grain per spike and thousand grain weight). It seems that A5 (0% chemical+ 100% compost) could not meet nutrient requirements with the progress of the growth stages, resulting in decreased grain yield and biological yield at harvest. As has been previously confirmed (Rehman *et al*. 2008), a higher absorption of nutrients, the enhanced soil fertility and improved soil physical conditions increases the growth and biochemical activities of the plant, resulting in an increase in the biological yield of plant. Similar results were reported by Akbari *et al*. (2011). They reported that organic and inorganic fertilizers in combinations have significantly increased wheat biological yield due to the improved soil physical conditions, enhanced soil fertility and improved stand establishment. It seems that the increasing biological yield of wheat in response to inoculation by these bio-fertilizers was related to the availability of most nutrients for the growth of this plant, which in turn increased photosynthesis, growth, grain filling and biological yield. Sherdil *et al*. (2019) reported that inoculation of wheat with PGPR increased biological yield of wheat. However, the increasing access of plants to nutrients, especially nitrogen, via the combined use of chemical fertilizers+ organic manure and bio-fertilizer cause an increase in growth and photosynthesis and also in the leaf area, which are the main factors underlying variation in biomass in integrated systems.

The effect of these treatments on harvest index might have been attributed to the nitrogen fertilizers which increased the total matter yield. This finding showed that chemical fertilizer and the combination of mineral and organic fertilization appeared to be more useful for harvest index than solely organic amendment. In line with this, improvements in wheat harvest index under using chemical+ organic fertilizer was reported by Chattha *et al*. (2019). Also, It seems that bio-fertilizer resulted in a higher dry matter per plant, which led to increased vegetative growth and, therefore, caused a more effective use of the incident radiation, increased photosynthesis and an increase in reproductive growth, grain yield and harvest index. Increases in the harvest index of crop by application of PGPRs was also reported by Akbari *et al*. (2011).

**Conclusion**

Extensive use of inorganic fertilizers leads to the dangerous ecological effects, and therefore the biological approaches such as compost and PGPR could be used to prevent further deterioration of the environment. In summary, the results of this experiment showed that the application of chemical nitrogen fertilizers+ sugarcane residue compost (50% chemical+ 50% compost) and PGPR increased wheat growth and yield. In addition, the results revealed that, compared to that without compost, less nitrogen fertilizer is needed to achieve a higher maximum wheat yield after combining the fertilizer with compost. Therefore, the conjunctive use of sugarcane residue compost and mineral fertilizers was shown a worthwhile approach to improve crop productivity. It is expected that crop productivity will be more sustainable with the combined application of organic and inorganic fertilizers than the sole application of inorganic fertilizers. Hence sugarcane residue compost, make it possible a cut down of mineral fertilizer doses reflecting in higher yields of wheat and better environmental sustainability. Generally, using chemical fertilizer+ sugarcane reside compost and inoculation of wheat with bio-fertilizer is an effective method to increase yield, and thus, could be recommended for enhancing the grain yield of wheat in the Ahwaz region.

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**Author Contributions**

AM, AKJ and MRMT planned the experiment, AM conduct the experiment and statistically analyzed the data, AM, AKJ and MRMT interpreted the results, AM made the write up.

**References**

Abbasi MK, MM Tahir (2012). Economizing nitrogen fertilizer in wheat through combinations with organic manures in Kashmir, Pakistan. *Agron J* 104:169-177.

Abedi T, A Alemzadeh, SA Kazemeini (2010). Effect of organic and inorganic fertilizers on grain yield and protein banding pattern of wheat. *Aust J Crop Sci* 4(6):384-389.

Akbari P, A Ghalavand, AM Modares-Sanavy, M Agha-Alikhani, S Shoghi-Kalkhoran (2011). Comparison of different nutritional levels and the effect of plant growth promoting rhizobacteria (PGPR) on the grain yield and quality of sunflower. *Aust J Crop Sci* 5(12):1570-1576.

Chattha MU, MU Hassan, L Barbanti, MB Chattha, I Khan, M Usman, A Ali, M Nawaz (2019). Composted sugarcane by-product press mud cake supports wheat growth and improves soil properties. *Intl J Plant Prod* 13:241-249.

[Chen](https://www.sciencedirect.com/science/article/pii/S2214514118300813?via%3Dihub" \l "!) H, A [Deng](https://www.sciencedirect.com/science/article/pii/S2214514118300813?via%3Dihub#!), W [Zhang](https://www.sciencedirect.com/science/article/pii/S2214514118300813?via%3Dihub#!), W [Li](https://www.sciencedirect.com/science/article/pii/S2214514118300813?via%3Dihub#!), Y [Qiao](https://www.sciencedirect.com/science/article/pii/S2214514118300813?via%3Dihub#!), T [Yang](https://www.sciencedirect.com/science/article/pii/S2214514118300813?via%3Dihub#!), C [Zheng](https://www.sciencedirect.com/science/article/pii/S2214514118300813?via%3Dihub#!), C [Cao](https://www.sciencedirect.com/science/article/pii/S2214514118300813?via%3Dihub#!), F [Chen](https://www.sciencedirect.com/science/article/pii/S2214514118300813?via%3Dihub#!) (2018). Long-term inorganic plus organic fertilization increases yield and yield stability of winter wheat. *Crop J* 6:589-599.

Di Benedetto NA, MR Corbo, D Campaniello, MP Cataldi, A Bevilacqua, M Sinigaglia, and Z Flagella (2017). The role of Plant Growth Promoting Bacteria in improving nitrogen use efficiency for sustainable crop production: a focus on wheat. *AIMS Microbiol* 3(3):413-434.

FAO. 2019. Statistical database. Food and Agriculture Organization. http://faostat3.fao.org

Guo L, G Wu, Y Li, C Li, W Liu, J Meng, H Liu, X Yua, G Jiang (2016). Effects of cattle manure compost combined with chemical fertilizer on topsoil organic matter, bulk density and earthworm activity in a wheat–maize rotation system in Eastern China. *Soil Till Res* 156:140-147.

Hammad HM, A Khaliq, F Abbas, W Farhad, S Fahad, M Aslam, S Mustafa, NW Ghulam, M Mubeen, HF Bakhat (2020). Comparative effects of organic and inorganic fertilizers on soil organic carbon and wheat productivity under arid region. *Commun Soil Sci Plant Anal*. <https://doi.org/10.1080/00103624.2020.1763385>

Hawkesford, MJ (2014). Reducing the reliance on nitrogen fertilizer for wheat production. *J Cereal Sci* 59:276-283.

Jiang Z, H Zheng, B Xing (2020). Environmental life cycle assessment of wheat production using chemical fertilizer, manure compost, and biochar amended manure compost strategies. *Sci Total Environ*. <https://doi.org/10.1016/j.scitotenv.2020.143342>

Kamali S, A Mehraban (2020). Nitroxin and arbuscular mycorrhizal fungi alleviate negative effects of drought stress on *Sorghum bicolor* yield through improving physiological and biochemical characteristics. *Plant Signal Behav*. <https://doi.org/10.1080/15592324.2020.1813998>

MAJ. 2019. Statistical yearbook. Ministry of Agriculture Jihad. http://www.maj.ir

Mandic V, V Krnjaja, Z Tomic, Z Bijelic, A Simic, D. R Muslic, and M Gogic (2015). Nitrogen fertilizer influence on wheat yield and use efficiency under different environmental conditions. *Chil J Agric Res*. 75(1):92-97.

Mecha B, S Alamerew, A Assefa, E Assefa, D Dutamo (2017). Correlation and path coefficient studies of yield and yield associated traits in bread wheat (*Triticum aestivum* L.) Genotypes. *Adv Plants Agric Res* 6(5):128-136.

Moshatati A, SA Siadat, Kh Alami-Saeid, AM Bakhshandeh, MR Jalal-Kamali (2017). The impact of terminal heat stress on yield and heat tolerance of bread wheat. *Intl J Plant Prod* 11:549-59.

Rana A, B Saharan, L Nain, R Prasanna, YS Shivay (2012). Enhancing micronutrient uptake and yield of wheat through bacterial PGPR consortia. *Soil Sci Plant Nutr* 58:573-582.

Rehman S, SK Khalil, A Rehman, and AUR Saljoqi (2008). Organic and inorganic fertilizers increase wheat yield components and biomass under rainfed condition. *Sarhad J Agric* 24:11-20.

Sheirdil R, R Hayat, X Zhang, A. N Akhtar, S Ali, M Ahmed, JZK Khattak, S Ahmad (2019). Exploring potential soil bacteria for sustainable wheat (*Triticum aestivum* L.) production. *Sustainability*. <https://doi.org/10.3390/su11123361>

Subhan A, QU Khan, M Mansoor, MJ Khan (2017). Effect of organic and inorganic fertilizer on the water use efficiency and yield attributes of wheat under heavy textured soil. *Sarhad J Agric* 33(4):582-590.

Wang J, R Li, H Zhang, G Wei, Z Li (2020). Beneficial bacteria activate nutrients and promote wheat growth under conditions of reduced fertilizer application. *BMC Microbiol*. <https://doi.org/10.1186/s12866-020-1708-z>

Xin XL, SW Qin, JB Zhang, AN Zhu, WL Yang, XF Zhang (2017). Yield, phosphorus use efficiency and balance response to substituting long-term chemical fertilizer use with organic manure in a wheat-maize system. *Field Crop Res* 208:27-33.

Yang YJ, T Lei, W Du, CL Liang, HD Li, JL Lv (2020). Substituting chemical fertilizer nitrogen with organic manure and comparing their nitrogen use efficiency and winter wheat yield. *J Agric Sci* <https://doi.org/10.1017/S0021859620000544>

Zhao Y, P Wang, J Li, Y Chen, X Ying, S Liu (2009). The effects of two organic manures on soil properties and crop yields on a temperate calcareous soil under a wheat–maize cropping system. *Eur J Agron* 31:36-42.

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| Table 1 Physical and chemical properties of soil (0-30 cm) and sugarcane residue compost | | |
| Physical and chemical properties | Soil | Sugarcane residue compost |
| EC (dS.m-1) | 3.6 | 2.2 |
| pH | 7.4 | 7.6 |
| Organic carbon (%) | 0.76 | 57.6 |
| Nitrogen (%) | 0.05 | 0.97 |
| Phosphorous (mg.kg-1) | 7.2 | 75.9 |
| Potassium (mg.kg-1) | 214 | 4850 |
| Bulk density (g.cm-3) | 1.21 | - |
| Texture | Silty clay | - |

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| Table 2 Variance analysis of the effect of chemical nitrogen fertilizer+ sugarcane residue compost and bio-fertilizer on measured traits | | | | | | | | | |
| S.O.V | df | MS | | | | | | | |
| Plant height | Spike length | Spike per m2 | Grain per spike | 1000 grain weight | Grain yield | Biological yield | Harvest index |
| Replication | 2 | 124.2\*\* | 0.60ns | 172.9ns | 7.1ns | 4.1\* | 6310ns | 379560ns | 0.0012ns |
| Chemical+compost (A) | 4 | 227.4\*\* | 3.79\*\* | 24084.6\*\* | 116.4\*\* | 11.9\*\* | 5830288\*\* | 45533380\*\* | 0.0048\*\* |
| Ea | 8 | 9.4 | 0.34 | 1352.0 | 4.6 | 0.5 | 52943 | 127360 | 0.0010 |
| Bio-fertilizer (B) | 1 | 166.6\*\* | 4.01\*\* | 33734.5\*\* | 142.1\*\* | 33.7\*\* | 10478430\*\* | 34005453\*\* | 0.00276\*\* |
| A\*B | 4 | 1.2ns | 0.06ns | 375.5ns | 0.6ns | 0.5ns | 27788ns | 127686ns | 0.0015ns |
| Eb | 29 | 3.8 | 0.03 | 503.6 | 2.3 | 0.6 | 33616 | 339480 | 0.0007 |
| C.V(%2 | | 2.3 | 2.3 | 6.6 | 4.7 | 2.1 | 5.8 | 5.6 | 8.9 |
| Ns, \* and \*\*: Non-significant, significant at 5% and 1% probability levels, respectively | | | | | | | | | |

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| Table 3 Mean comparisons of measured traits in different chemical nitrogen fertilizer+ sugarcane residue compost levels | | | | | | | | |
| nitrogen chemical fertilizer+ sugarcane residue compost | Plant height (cm) | Spike length (cm) | Spike per m2 | Grain per spike | 1000 grain weight (g) | Grain yield (kg/ha) | Biological yield (kg/ha) | Harvest index (%) |
| A1 (100% chemical) | 81.9b | 8.4bc | 327.5bc | 33.0b | 37.0bc | 3225c | 10570c | 30.3a |
| A2 (75% chemical+ 25% compost) | 87.2a | 8.9ab | 374.3ab | 35.7ab | 37.9ab | 3775b | 12613b | 29.5a |
| A3 (50% chemical+ 50% compost) | 90.2a | 9.2a | 417.5a | 37.5a | 38.8a | 4331a | 13403a | 32.3a |
| A4 (25% chemical+ 75% compost) | 78.0b | 8.0c | 304.1c | 29.4c | 36.4c | 2683d | 8320d | 31.8a |
| A5 (100% compost) | 73.3b | 7.2d | 253.1d | 26.8c | 35.2d | 1780e | 6923e | 25.1b |
| Means in each column, followed by a similar letter(s) are not significantly different at 5% probability level using LSD Test. | | | | | | | | |

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| Table 4 Mean comparisons of measured traits in different bio-fertilizer levels | | | | | | | | |
| bio-fertilizer | Plant height (cm) | Spike length (cm) | Spike per m2 | Grain per spike | 1000 grain weight (g) | Grain yield (kg/ha) | Biological yield (kg/ha) | Harvest index (%) |
| Control | 79.8b | 8.0b | 301.8b | 30.3b | 36.0b | 2568b | 9301b | 26.8b |
| Treatment | 84.5a | 8.7a | 368.8a | 34.7a | 38.1a | 3750a | 11430a | 32.8a |
| Means in each column, followed by a similar letter(s) are not significantly different at 5% probability level using LSD Test. | | | | | | | | |

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| Table 5 Simple correlation between measured traits (n=40) | | | | | | | |
| Traits | Plant height | Spike length | Spike per m2 | Grain per spike | 1000 grain weight | Grain yield | Biological yield |
| Spike length | 0.92\*\* |  |  |  |  |  |  |
| Spike per m2 | 0.76\*\* | 0.77\*\* |  |  |  |  |  |
| Grain per spike | 0.77\*\* | 0.84\*\* | 0.84\*\* |  |  |  |  |
| 1000 grain weight | 0.84\*\* | 0.80\*\* | 0.80\*\* | 0.78\*\* |  |  |  |
| Grain yield | 0.82\*\* | 0.84\*\* | 0.92\*\* | 0.90\*\* | 0.87\*\* |  |  |
| Biological yield | 0.88\*\* | 0.88\*\* | 0.89\*\* | 0.92\*\* | 0.83\*\* | 0.94\*\* |  |
| Harvest index | 0.38\*\* | 0.46\*\* | 0.60\*\* | 0.52\*\* | 0.63\*\* | 0.73\*\* | 0.47\*\* |
| \*\*: Significant at 1% probability levels | | | | | | | |