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ASSESSING THE FRACTIONAL IMPACT OF MUNICIPAL SOLID WASTE AS A FERTILIZER ON VARIOUS ATTRIBUTES OF PLANTS

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Abstract

During 2017, this study was carried out to see how various fractions of fertilizer (municipal solid waste) affected food crop development, yield, quality metrics, and macronutrient content, and also post-harvest physicochemical characteristics of soil. The experiment was set up in such a way that it was absolutely random (CRD). In comparison to their sole application, the fractional use of fertilizer resulted in the highest plant height (135.9 cm), stem girth (2.45 cm), leaf area (341.4 cm2), and number of leaves/plant (11.66). The maximum values of quality parameters such as ash (2.48%), crude fat (5.22%), crude fiber (2.62 5%), and crude protein (14.98%) were found at T2 treatment (50% loamy soil & 50% MSW), higher moisture contents (12.69%) were found in manure treatment. The values of nitrogen (2.39%) and potassium content (1.37%) were also higher in mix loamy soil and fertilizer treatment. Furthermore, post-harvest physicochemical parameters of the soil also improved by combined use of soil and fertilizers. Hence, combination of loamy soil and organic fertilizer is thus recommended to get better growth, yield and quality of plants.

Key words: Growth; Macro-nutrient; Physicochemical; Proximate; Food crops.

Introduction

Meeting the feeding needs of the world's constantly growing population is one of the world's most difficult concerns (Unver *et al*., 2015; Matemilola & Elegbede, 2017). The soil's fertility is dwindling day by day. Soil erosion, nutrient leaching, land degradation, and crop harvesting are the main causes of soil infertility (Mbah & Onweremadu, 2009; Dogan *et al*., 2014a, b; Khan *et al*., 2018a). Crop yields per capita are steadily declining due to nutrient supply imbalances, nutrient leaching, and a lack of fertility reestablishing inputs (Ajayi *et al*., 2007; Ugulu *et al*., 2009; Ahmad *et al.*, 2018a, b). As a result, proper measures for restoring soil fertility are required in order to obtain an optimal crop yield to meet market demand (Damiyal *et al*., 2017; Khan *et al*., 2018b). On agricultural land, the best approach of reestablishing soil fertility is to employ manure (Khan *et al*., 2017). Because nutrients are readily available, inorganic fertilizers improve plant growth and output. However, the continued use of synthetic fertilizers has negative consequences for the land and the environment. It causes ground and surface water contamination, soil acidification, nutrient loss, enhanced sensitivity to harmful insects and a decrease in microbial communities (Chen, 2006). Long-term application of chemical fertilizers causes unevenness in the availability of various other nutrients (Kanzaria *et al*., 2010). In light of above-mentioned argument and due to its high cost, its use is restricted among small-scale and resource-poor farmers. As a result, in the contemporary era, focus has shifted to the use of organic fertilizers (Ramadan & Adam, 2007).

United Nations Organizations suggested the application of organic manure to agricultural land (Anon., 2001). Water, nitrogen, phosphorus and potassium are the limiting factor during the growth of plant. Organic manure such as composted municipal solid waste are the valuable source of nitrogen, phosphorus, potassium, micronutrients and organic matter (Berry *et al*., 2003). Unlike artificial fertilizers, which contain an excess of nutrients, organic manures contain growth-promoting compounds, making them a great fertilizer for enhancing soil fertility and crop output (Dogan & Ugulu, 2013).

Numerous studies have shown that neither mineral nor organic fertilizers are sufficient to maintain crop productivity (Durkan *et al*., 2011). Rather, combining the two has proven to be more effective in increasing crop development and output while also providing plants with a balanced quantity of micro, main, and secondary nutrients (Milkha & Aulakh, 2010). The amendment of soil with different fractions of MSW manure is a sensible way to use such manure for maintaining soil fertility.

Plant development and yield are improved when organic manure and loamy soil are applied together. Because this treatment helps to reduce environmental hazards while also providing micro and macronutrients to plants (Wailare & Kesarwani, 2017).

The study's goals were to: (1) estimate the fractional influence of municipal solid waste on plant growth and yield metrics; (2) determine the proximate composition of plants; (3) examine the physicochemical parameters of soil; and (4) analyse the macronutrient content of plants.

Materials and Method

The experiment was conducted in 2017 at the Department of Botany at the University of Sargodha in Punjab, Pakistan. Sargodha has a severe climate, with temperatures ranging from 45 to 50 degrees Celsius in the summer and 4 to 25 degrees Celsius in the winter. The average yearly rainfall is roughly 410 mm (Ahmad *et al*., 2019).

Initial soil fertility status: The soil for the experiment was collected from a plant nursery in Sargodha City. Before being crushed into a fine powder and sieved at 2 mm, soil samples were air dried. The soil samples were maintained in polythene bags and physicochemical parameters were determined at the Soil and Water Testing Laboratory for Research Sargodha. Soil's initial physical and chemical characteristics are given in Table 1.

Properties of manure used in the experiment: Collection of Municipal solid waste (MSW) was done from different sources, namely waste disposal areas, fruit and vegetables markets and the waste collecting canals of Sargodha. There are two stages in MSW manuring process: Degradation and Maturation. In the first stage, biodegradable compounds were composted via aerobic fermentation while complex organic compounds were degraded in the second stage of this process. All the particles such as plastic pieces, stones, roots were removed from the manure and preceded them through a 2mm sieve. The composted MSW is ground into a fine powder and blended to achieve uniformity in the samples using a mortar and pestle. The chemical compositions of the soil and MSW compost are shown in Table 1.

Plant cultivation and treatment layout: We filled plastic sacks with dirt and manure and placed them on the ground. The experiment was set up in a CRD method with five repetitions. During the first week of February 2017, seeding took place. Several plants' healthy seeds were sown in plastic bags with a capacity of 10 kg. The bags had previously been filled with a mixture of soil and various manure fractions at 25 percent MSW (T1), 50 percent MSW (T2), and 75 percent MSW (T3), and allowed to mineralize for 3 weeks with the exception of pots that only contained soil. All of the plants in each treatment received the same amount of water. The data on growth and yield metrics of different plants was collected using standard methodologies.

Data collection

Determination of growth parameters: Varying growth metrics such as plant height, shoot length, root length, leaf area, and the number of leaves/plants were calculated for the crops treated with different fractions of MSW. A measuring tape was used to measure the plant's height (cm) from the base to the tip of the highest leaf. By visual examination, the number of leaves/plants on each plant in a container was calculated, and the mean was taken. By multiplying the leaf length by the leaf width (the widest region of the leaf) and the correction factor, the leaf area (cm2) was calculated (0.75).

Soil sampling: A soil sample was gathered from each plastic bag during harvest. Soil samples were taken from the top to the bottom of the soil profile, with depths ranging from 0 to 20 cm. Soil samples were air dried for a few days before being crushed and sieved at 2 mm with a mortar and pestle. The sieved soil sample was sealed in polythene bags and dried in the oven at 72°C for two days (Khan *et al*., 2019).

Determination of physicochemical parameters of soil: Organic matter, electrical conductivity (EC), pH, available P, and available K were determined as physicochemical parameters of soil (Arshi & Khan, 2018).

Proximate analysis: Proximate analysis of samples was done by using the following procedures and formulas (Anon., 2000).

Moisture content was determined as following:

$$\text{Moisture content} = \frac{\text{W initial} - \text{W final}}{\text{W final}} \times 100$$

The percentage of ash contents were found as following:

$$\text{Ash} = \frac{\text{W ash}}{\text{W sample}} \times 100$$

The percentage of crude fat was calculated by using as following:

$$\text{Crude fat} = \frac{(\text{W2} - \text{W1}) \times 100}{\text{S}}$$

The percentage of fiber was calculated by using following equation:

$$\text{Crude fiber} = \frac{\text{Final weight after ignition} \times 100}{\text{Weight of sample}}$$

Kjeldahl's nitrogen was multiplied by 6.25 to get crude protein.

The total carbohydrate was calculated by subtracting moisture, ash, crude fat, crude fibre, and crude protein from the hundred.

Determination of macro-nutrients: Determination of nitrogen was done by using Kjeldhal's method (Anon., 2000). A flame atomic absorption spectrophotometer was used to determine the potassium concentration.

Statistical analysis: SPSS version 23 was utilized as the statistics application. The difference in mean between different treatments was determined using one-way study of variance (Steel *et al*., 1997). The data was presented as arithmetic means with a standard deviation.

Results

Post-harvest physicochemical parameters of soil: The effects of various MSW treatments on soil pH, EC, organic matter, available P, and available K were significant ($p \leq 0.05$) (Table 2). In all treatments, the soil texture was loam.

The pH of soil varied from 6.93 to 7.46 in all treatments. At all treatments, the EC of soil ranged from 2.86 to 5.18 dS m^{-1}. The OM (%) of soil at T_0, T_1, T_2, and T_3 was 1.04. 1.11, 1.32, and 1.18 correspondingly. The values of available P (mg kg^{-1}) at various treatments were 17.20, 16.0, 17.50, and 15.50, correspondingly. The available K among all treatments were 180, 224, 416, and 410 mg kg^{-1} correspondingly (Table 3).

Growth and yield parameters

Germination: The result from ANOVA depicted a significant effect of MSW on germination of food crops ($p \leq 0.05$) (Table 4). The sequence of germination rate was: $T_2 > T_3 > T_1 > T_0$.

Plant height: Fertilizers had a substantial impact on plant height (p0.05) (Table 4). T2 (130.7) had the highest plant height (cm), followed by T3 (127.8), T1 (123.3), and control (106), in that order (Table 5).

Stem girth: Manure administration had a significant (p0.05) effect on stem girth (Table 4). The stem girth (cm) was noticed in following decreasing order: T_2 (1.79)> T_3 (1.73)> T_1 (1.56)> Control (1.31) (Table 5).

Leaf area: The findings of the ANOVA of data showed that treatments had a significant influence on leaf area (p0.05) (Table 4). The leaf area (cm2) was found in following order: T_2 (326.2)> T_3 (311.5)> T_1 (280.9)> Control (193.2) (Table 5).

Number of leaves/plants: The ANOVA revealed that treatments had a significant impact on the number of leaves/plant (Table 4). The following trend was noticed for the number of leaves/plants: T_2 (10.66)> T_1(10.33)> Control (8.66) (Table 5).

Proximate composition of plants

Moisture: The ANOVA revealed that treatments had a substantial impact on plant moisture content (Table 6). T2 (12.69) had the highest moisture content, followed by T3 (10.01), and T1 (9.81), with control (8.77) having the lowest (Table 7).

Ash: Treatments exhibited a significant impact on ash content of plants ($p \leq 0.05$) (Table 6). Ash content (%) was found in following descending sequence: T_2 (2.35)> T_1 (2.25)> T_3 (2.03)> Control (1.45) (Table 7).

Crude fat: Fertilizer application significantly affected the crude fat of plants ($p \leq 0.05$) (Table 6). The crude fat (%) was found in following descending sequence: T_2 (4.59)> T_3 (4.32)> T_1 (3.60)> Control (2.14) (Table 7).

Crude fiber: The ANOVA findings revealed that treatments had a significant impact on the crude fibre content of plants (Table 6). The crude fibers (%) were present in following order: T_2 (2.26)> T_3 (2.08)> T_1 (1.93)> Control (1.80) (Table 7).

Crude protein: The crude protein concentration was significantly affected by organic and synthetic fertilizers (Table 6). For crude protein (percentage), the following order was observed: T2 (14.76)> T3 (14.08)> T1 (13.87)> Control (12.44). (Table 7).

Table 1. Preliminary physical and chemical properties of soil, and MSW manure used in the experiment.

Parameter	pH	EC (dS m^{-1})	Available P (mg kg-1)	Available K (mg kg-1)	Organic matter (%)	Texture
Soil	8.1	5.72	10.3	140	1.25	Loam
Manure	8..0	36.10	14.8	160	1.25	-

Table 2. Analysis of variance for post-harvest physicochemical parameters of the soil.

Source of variation	Mean square				
	pH	EC	OM	Av. P	Av. K
Treatments	0.126***	3.363***	0.037***	59.901***	44554.26***
Error	0.003	0.005	0.001	0.664	15.867

***: Significant at 0.001 level, EC: Electrical conductivity, OM: Organic matter, Av. P: Available P, Av. K: Available K

Table 3. Physico-chemical parameters of soil (Mean ± S.E).

Treatments	pH	EC (dS m-1)	OM (%)	Av. P(mg kg-1)	Av. K(mg kg-1)	Texture
T_0	6.93 ± 0.05	2.860 ± 0.09	1.040 ± 0.03	7.20 ± 1.02	180 ± 3.01	Loam
T_1	7.03 ± 0.03	3.230 ± 0.06	1.110 ± 0.04	16.00 ± 1.05	224 ± 4.04	Loam
T_2	7.46 ± 0.04	5.043 ± 0.03	1.320 ± 0.03	17.50 ± 0.78	416 ± 2.08	Loam
T_3	7.23 ± 0.05	3.680 ± 0.07	1.180 ± 0.03	15.50 ± 0.62	410 ± 5.09	Loam

T_0: Control, T_1: 25% of MSW & 75% of loamy soil, T_2: 50% of MSW & 50% of loamy soil, T_3: 75% of MSW and 25% of loamy soil, EC: Electrical conductivity, OM: Organic matter, Av. P: Available P, Av. K: Available K

Table 4. Plant growth and yield parameters (Mean ± S.E).

Source of variation	Mean square				
	Germination	Plant height	Stem girth	Leaf area	No. of leaves/p lant
Treatments	276.04**	392.7***	0.538**	10393.4***	3.76***
Error	72.91	51.57	0.090	95.447	0.33

, *: Significant at 0.01 and 0.001 levels

Table 5. Mean concentration of growth and yield parameters.

Treatments	Germination (%)	Plant height (cm)	Stem girth (cm)	Leaf area (cm2)	No. of leaves/plant
T_0	66.66 ± 5.53	106.0 ± 8.71	1.31 ± 0.12	193.2 ± 15.5	8.666 ± 0.67
T_1	79.16 ± 5.78	123.3 ± 8.96	1.56 ± 0.13	280.9 ± 14.9	10.33 ± 0.88
T_2	87.50 ± 7.25	130.7 ± 8.42	1.79 ± 0.15	326.2 ± 20.1	10.66 ± 0.72
T_3	83.33 ± 6.66	127.8 ± 9.49	1.73 ± 0.11	311.5 ± 16.7	9.666 ± 0.69

T_0: Control, T_1: 25% of MSW & 75% of loamy soil, T_2: 50% of MSW & 50% of loamy soil, T_3: 75% of MSW and 25% of loamy soil

Table 6. Mean square for the proximate composition of plants.

Source of variation	Mean square					
	Moisture	Ash	Crude fat	Crude fiber	Crude protein	Carbohydrates
Treatments	10.53***	0.49***	4.16***	0.30***	2.88***	61.74***
Error	1.16	0.04	0.12	0.23	0.23	0.52

***: Significant at 0.001 level

Table 7. Mean concentration of proximate composition of plants.

Treatment	Moisture (%)	Ash (%)	Crude fat (%)	Crude fiber (%)	Crude protein (%)	Carbohydrates (%)
T_0	8.77 ± 1.44	1.45 ± 0.16	2.14 ± 0.64	1.80 ± 0.01	12.44 ± 0.37	73.4 ± 2.61
T_1	9.81 ± 0.03	2.25 ± 0.05	3.60 ± 0.03	1.93 ± 0.08	13.87 ± 0.11	68.54 ± 2.10
T_2	12.69 ± 1.07	2.35 ± 0.02	4.59 ± 0.43	2.26 ± 0.13	14.76 ± 0.11	63.35 ± 1.47
T_3	10.01 ± 0.06	2.03 ± 0.05	4.32 ± 0.07	2.08 ± 0.03	14.08 ± 0.07	67.48 ± 1.16

T_0: Control, T_1: 25% of MSW & 75 % of loamy soil, T_2: 50% of MSW & 50% of loamy soil, T_3: 75% of MSW and 25% of loamy soil

Table 8. Mean square for macro-nutrients in plants.

Source of variation	Mean square	
	N	K
Treatments	0.047***	0.400***
Error	0.006	0.002

Key: ***: Significant at 0.001 levels

Table 9. Mean concentration of macro-nutrients in plants

Treatment	N (%)	K (%)
T_0	1.991 ± 0.05	0.476 ± 0.03
T_1	2.219 ± 0.09	1.213 ± 0.05
T_2	2.347 ± 0.07	1.293 ± 0.04
T_3	2.252 ± 0.09	1.240 ± 0.02
Standard limits	2-5a	1-5a

T_0: Control, T_1: 25% of MSW & 75% of loamy soil, T_2: 50% of MSW & 50% of loamy soil, T_3: 75% of MSW and 25% of loamy soil, Source: [a]Bennett (1993)

Carbohydrates: The percentage of carbohydrates were significantly affected by different treatments ($p \leq 0.05$) (Table 6). The % carbohydrate was found in following ranking order: Control (73.4)> T_1 (68.54)> T_3 (67.48)> T_1 (63.63) (Table 7).

The concentration of macro-nutrients: Treatments significantly affected the concentration of nitrogen and potassium in the plants ($p \leq 0.05$) (Table 8). The % N in five treatments ranged from 0.19 to 2.39 respectively. The % K in all treatments varied from 0.47 to 1.37 correspondingly (Table 9).

Discussion

The manure from municipal solid trash is applied to agricultural land to boost crop productivity. T2 therapy yielded the highest pH, followed by T3, T1, and control. The decomposition of organic manure increased the amount of basic plant nutrients in the soil, which helps to raise soil pH (Ahmad *et al*., 2018c). The findings were comparable to those of Islam *et al*., (2013), who found that adding manure to the soil raised the pH. The soil EC in the current study was higher than that reported by Pratap *et al*., (2016). T1, T2, and T3 treatments have greater organic matter than control. The increased OM in T2 could be attributable to the fact that T2 is a nutrient storage compartment. Zhao *et al*., (2009) also found that using MSW alone or in combination with synthetic fertilizers resulted in higher OM than using chemical fertilizers alone. T2 yielded the highest levels of accessible P in the soil. The greater available P values at T2, T3 were attributable to the formation of organic acid and mineralization of organic P, resulting in P fixing and increased availability. Our findings backed up the findings of Islam *et al*., (2013), who found that using organic and inorganic fertilizers separately and in combination increased soil accessible P when compared to control. The pH in this study was greater, while the OM and accessible P were lower than those reported by Almaz *et al*., (2017). The increase in available K in all fertilizer treatments was observed. Ahmad *et al*., (2013) also reported a higher level of OM, available P and K at 50% organic manure + 50% of soil.

Lower germination was noticed in control pots without any amendment, while the manure-amended pots give maximum germination due to the higher moisture holding ability (Chiroma *et al*., 2006) and soften seedbed as compared to control. No prominent difference was noticed in the germination of pots amended with different fractions of MSW.

It's possible that the higher plant height at T2 is related to the abundance of nutrients. Because of the substantial nutrient availability throughout the growing period, MSW application significantly boosted plant height. MSW has a far higher nutritional value than cow manure (Daur *et al*., 2015). In comparison to current findings, Mitchell & Tu, (2005) and Warren *et al*., (2006) reported similar results. Due to a balanced supply of nutrients, the application of varied fractions of MSW results in maximum plant height and other growth indices (Channabasanagowda *et al*., 2008). Sharma *et al*., (2005) discovered a comparable increase in plant height. El-Ghamry *et al*., (2009) reported that combining MSW with synthetic fertilizers resulted in maximum plant height.

The stem girth of plants was increased due to a substantial supply of nutrients. When the plant was fertilized with both organic and inorganic fertilizers, the stem girth reached its maximum. Afe *et al*., (2015) discovered a similar increase in stem girth by combining various fertilizers. The increase in stem girth could be attributed to cell enlargement and higher mitotic division, which creates a huge photosynthetic sink in the stem. The plant will not lodge if the stem girth is improved (Kareem *et al*., 2017). Maximum leaf area was noticed in plants treated with the T_2 and T_3. This might be due to the high availability of nitrogen, which increases the size of leaf and vegetative growth. Balyeri *et al.,* (2016) reported similar increase in leaf area, growth and proximate composition of aromatic pepper as compared to current findings.

Our findings matched those of Wailare & Kesarwani, (2017), who found a similar increase in leaf area after applying MSW manure. As the plant's leaf area grows, it collects more light, resulting in higher photosynthetic activity (Adekayode & Olojugba, 2010). Our findings were consistent with those of Qasim *et al*., (2001), who found that combining soil amendments resulted in more leaves/plant. According to Ekesiobi *et al*., (2015), the combined application of MSW resulted in the greatest number of leaves/plants when compared to their soil application. The photosynthetic activity of the plant may be positively influenced by an increase in the number of leaves; hence the number of leaves is an important growth parameter that could boost the yield of the plant.

The moisture content in the current investigation was found to be higher than those recorded by Saeed *et al*., (2013). The results revealed that various manure applications enhanced the moisture content of plants compared to control. Various studies from the past showed that the lower moisture content enhanced the susceptibility of plants to various diseases. The greater moisture content in T2 and T3 could be attributable to the soil's higher moisture retention ability and decreased moisture evaporation (Rafiq *et al*., 2010). So, the manure application provides sufficient nutrients to enhance the yield and moisture content of plants (Ullah *et al*., 2010). Ash content of food crop is used to determine the mineral present in it (Mbatchou & Dawda, 2013). It is also used to estimate the extent of essential minerals in a particular food crop (Edeogu *et al*., 2007). The difference in ash content in various treatments might be due to the difference in the mineral composition of soil due to various soil amendments (Shayo *et al*., 2006). Residue content in our findings was in accordance with Mbatchou & Dawda, (2013), while higher than Thomas *et al*., (2013).

The T2 treatment produced the high contents of crude fat. The current study's crude fat levels were higher than those reported by Saeed *et al*., (2013). Crude fat is a key component of plants, and it has numerous health benefits for humans. Plants cultivated in MSW treated soil had much higher crude fat content than plants grown in control soil. Earlier studies (Farhad *et al*., 2009) also stated that manure application is significant in improving plant quality. In comparison to other treatments, manure treatments had a higher level of crude fibre.

The results exposed that the best crude protein was found at T_2 treatment. Hence the mixture of soil and MSW contains a sufficient amount of N and various other minerals. Nitrogen plays a crucial role in protein synthesis. These findings were supported by many other workers. Our findings were similar to the results of Adam, (2004) who stated that N enhanced the quality of plants by increasing the production of protein in plants. The values of crude protein in present findings were similar to those given by Yossif & Ibrahim, (2013) in plants. Plants contain a large amount of carbohydrate. Higher carbohydrate content indicated greater energy because carbohydrates store a large amount of energy (Odedire *et al*., 2008).

In comparison to the current work, David *et al*., (2016) found a comparable spectrum of carbohydrates in plants. The carbohydrate content of the plants studied in this study was lower than that of Kavitha & Parimalavalli, (2014). The levels of N and K were determined to be within ranges of N (2-5%) and K (1-5%) (Nadeem *et al*., 2019). T2 has the highest concentration of nitrogen. In comparison to the current findings, Farhad *et al*., (2009) found the highest level of N in manure treatment. In comparison to the current results, Farhad *et al*., (2009) produced comparable results. The T2 treatment had a greater potassium concentration in the plants. Earlier research has also demonstrated that using MSW increased plant K content (Ahmad *et al*., 2008). Similarly, Ning *et al*., (2014) used organic manure to achieve the maximum level of K in plants.

Conclusion

It was concluded that the maximum values of growth, yield and proximate composition of plants were found in mix MSW and loamy soil treatment collectively as compared to their sole application. MSW along with loamy soil provide sufficient macro-nutrients to enhance the growth of plant and progressively increased the product and quality of plants. The application of MSW manure is thus recommended to smallholder farmers for sustainable production of crops.

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References

Adam, M.Y. 2004. Effect of seed rate and nitrogen on growth and yield of teff grass (*Eragrostis teff Zucc.*) Trotter. M.Sc. Thesis. Faculty of Agriculture, University of Khartoum, Sudan.

Adekayode, F.O. and M.R. Olojugba. 2010. The utilization of wood ash as manure to reduce the use of mineral fertilizer for improved performance of maize (*Zea mays* L.) as measured in the chlorophyll content and grain yield. *J. Soil Sci. Environ. Manag*., 1(3): 40-45.

Afe, A.I., S. Atanda, M.O. Aduloju, S.K. Ogundare and A.A. Talabi. 2015. Response of maize (*Zea mays* L.) to combined application of organic and inorganic (soil and foliar applied) fertilizers. *Afr. J. Biotech.*, 14(44): 3006 3010.

Ahmad, K., A. Ashfaq, Z.I. Khan, H. Bashir, M. Sohail, N. Mehmood and Y. Dogan. 2018b. Metal accumulation in *Raphanus sativus* and *Brassica rapa*: An assessment of potential health risk for inhabitants in Punjab, Pakistan. *Environ. Sci. Pollut. Res.*, 25(8): 16676-16685.

Ahmad, K., K. Nawaz, Z.I. Khan, M. Nadeem, K. Wajid, A. Ashfaq B. Munir, H. Memoonas, M. Sanas, F. Shaheen and R. Kokab. 2018a. Effect of diverse regimes of irrigation on metals accumulation in wheat crop: An assessment-dire need of the day. *Fresen. Environ. Bull*., 27(2): 846-855.

Ahmad, K., K. Wajid, Z.I. Khan, I. Ugulu, H. Memoona, M. Sana, K. Nawaz, I.S. Malik, H. Bashir and M. Sher. 2019. Evaluation of potential toxic metals accumulation in wheat irrigated with wastewater. *Bull. Environ. Contam. Toxicol*., 102(6): 822-828. https://doi.org/10.1007/s00128-019-02605-1.

Ahmad, K., R. Kokab, Z.I. Khan, A. Ashfaq, H. Bashir, M. Munir, M. Sher, K. Wajid, H. Memona, M. sana, I.R. Noorka. 2018c. Assessment of heavy metals in wheat variety ‘‘Chagi-2’’ under short-term wastewater irrigation. *Biologia (Pakistan),* 64(1): 15-25.

Ahmad, R., M. Naveed, M. Aslam Z.A. Zahir, M. Arshad and G. Jilani. 2008. Economizing the use of nitrogen fertilizer in wheat production through enriched compost. *Renew. Agric. Food Syst.,* 23: 243-249.

Ahmad, W., Z. Shah, F. Khan, S. Ali and W. Malik. 2013. Maize yield and soil properties as influenced by integrated use of organic, inorganic and biofertilizers in a low fertility soil. *Soil Environ*., 32(2): 121-129.

Ajayi, O.C., F.K. Akinnifesi, G. Sileshi and S. Chakeredza. 2007. Adoption of renewable soil fertility replenishment technologies in the southern African region: Lessons learnt and the way forward. In *Natural resources forum* Oxford, UK: Blackwell Publishing Ltd, pp. 306-317.

Almaz, M.G., R.A. Halim, M.Y. Martini and A.W. Samsuri. 2017. Integrated application of poultry manure and chemical fertilizer on soil chemical properties and nutrient uptake of Maize and Soybean. *Malays. J. Soil Sci.,* 21: 13-28.

Anonymous. 2000. Official methods of analysis of AOAC international, 17^{th} Ed. AOAC International: Gaithersburg, MD, USA.

Anonymous. 2001. *Guidelines for the production, processing, labeling and marketing of organic produced products*. GL-32-1999. Rev.

Arshi, I. and T. Khan. 2018. Analysis of soil quality using physico-chemical parameters with special emphasis on fluoride from selected sites of Sawai Madhopur Tehsil, Rajasthan. *Int. J. Environ. Sci. Nat. Res*., 12(5): 555847. DOI, 10.19080/IJESNR.2018.12.555847

Balyeri, P.K., G.T. Otitoju, N.E. Abu and S. Umeh. 2016. Poultry manure influenced growth, yield and nutritional quality of containerized aromatic pepper (*Capsicum annum* L., var. “Naskka Yellow”). *Afr. J. Agric. Res*., 11(23): 2013-2023.

Berry, P.M., E.A. Stockdale, R.S. Bradley, L. Philipps, K.A. Smith and E.I. Lord. 2003. N, P and K budgets for crop rotations on nine organic farms in the UK. *Soil Use Manag.,* 19: 112-118.

Channabasanagowda, N.K., B. Patil, B.N. Patil, J.S. Awaknavar, B.T. Ninganurn and R. Hunje. 2008. Effect of organic manures on growth, seed yield and quality of wheat. Karnataka. *J. Agric. Sci.,* 21(3): 366-368.

Chen, J.H. 2006. The combined use of chemical and organic fertilizers and/or biofertilizer for crop growth and soil fertility. In *International workshop on sustained management of the soil-rhizosphere system for efficient crop production and fertilizer use*. Land Development Department Bangkok, Thailand, 16: 20.

Chiroma, A.M., O.A. Folorunso and A.B. Alhassan. 2006. The effects of land configuration and wood-shavings mulch on the properties of a sandy loam soil in northeast Nigeria. 1. Changes in chemical properties. *Tropicultura*, 24(3): 129-134.

Damiyal, D.M., W. Manggoe, S. Ali, D.Y. Dalokom and I.M. Mashat. 2017. Effect of cattle manure and inorganic fertilizer on the growth and yield of hybrid maize (*Zea mays* L.). *World Res. J. Agric. Sci.,* 4(1): 102-110.

Daur, I., A. Abusuwar and F. Alghabari. 2015. Exploitation of EM. 1-treated blends of organic resources and humic acid for organic Berseem (*Trifolium alexandrinum* L.) production. *Turk. J. Field Crops,* 20: 125-130.

David, I.A., A.N. Nwanyinnaya, I.U. Ezekiel and S.I. Chinelo. 2016. Comparative proximate analysis of maize and sorghum bought from Ogbete main market of Enugu State, Nigeria. *Greener J. Agric. Sci.,* 6(9): 272-275.

Dogan, Y. and I. Ugulu. 2013. Medicinal plants used for gastrointestinal orders in some districts of Izmir Province, Turkey. *Stud. Ethno-Med.,* 7: 149-162.

Dogan, Y., M.C. Unver, I. Ugulu, M. Calis and N. Durkan. 2014b. Heavy metal accumulation in the bark and leaves of *Juglans regia* planted in Artvin City, Turkey. *Biotech. Biotechnol. Equip.,* 28: 643-649.

Dogan, Y., S. Baslar and I. Ugulu. 2014a. A study on detecting heavy metal accumulation through biomonitoring: Content of trace elements in plants at Mount Kazdagi in Turkey. *Appl. Ecol. Environ. Res.,* 12: 627-636.

Durkan, N., I. Ugulu, M.C. Unver, Y. Dogan and S. Baslar. 2011. Concentrations of trace elements aluminum, boron, cobalt and tin in various wild edible mushroom species from Buyuk Menderes River Basin of Turkey by ICP-OES. *Trace Elem. Elect.,* 28(4): 242-248. http://doi.org/10.5414/TEX01198.

Edeogu, C.O., F.C. Ezeonu, A.N.C. Okaka, C.E. Ekuma and S.O. Elom. 2007. Proximate composition of staple food crops in Ebonyi State (South Eastern Nigeria). *Int. J. Biotech. Biochem*., 3(1): 1-8.

Ekesiobi, I.A., O.O. Ndukwe, C.I. Ezeano, R.A. Odukwe and E.L.C. Nnabuife. 2015. Influence of complementary rates of poultry manure and urea fertilizers on growth and yield of maize (*Zea mays* L. Walp) in Southeastern Agro-ecology Zone. *Int. J. Appl. Sci. Engi.,* 3(1): 8-13.

El-Ghamry, A.M., A.M.A. El-Hamid and A.A. Mosa. 2009. Effect of farmyard manure and foliar application of micronutrients on yield characteristics of wheat grown on salt affected soil. *Am. Eurasian J. Agric. Environ. Sci.,* 5(4): 460-465.

Farhad, W., M.F. Saleem, M.A. Cheema and H.M. Hammad. 2009. Effect of different manures on the productivity of spring maize (*Zea mays* L). *J. Ani. Plant Sci.,* 19(3): 122-125.

Islam, M.R., M.A.H. Chowdhury, B.K. Saha and M.M. Hasan. 2013. Integrated fertilization on soil fertility, growth and yield of tomato. *J. Bangladesh Agric. Uni*., 11(1): 33-40.

Kanzaria, K.K., G.S. Sutaria, K.N. Akbari, V.D. Vora and D.R. Padmani. 2010. Effect of integrated nutrient management on productivity of pearl millet and soil fertility of sandy loam soils under rain fed conditions. *An Asian J. Soil Sci.,* 5: 154-156.

Kareem, I., O.B. Jawando, E.K. Eifediyi, W.B. Bello and Y. Oladosu. 2017. Improvement of growth and yield of maize (*Zea mays* L.) by poultry manure, maize variety and plant population. *Cercetari Agronomice in Moldova*, 4(172): 51-64.

Kavitha, S. and R. Parimalavalli. 2014. Effect of processing methods on proximate composition of cereal and legume flours. *J. Human Nutrit. Food Sci.,* 2(4): 1051.

Khan, A., M.Z. Afridi, M. Airf, S. Ali and I. Muhammad. 2017. A sustainable approach toward maize production: effectiveness of farm yard manure and urea N. *Ann. Biol. Sci.,* 5(1): 8-13.

Khan, Z.I., H. Safdar K. Ahmad, I. Ugulu K. Wajid, H. Bashir and Y. Dogan. 2018a. Manganese bioaccumulation and translocation of in forages grown in soil irrigated with city effluent: an evaluation on health risk. *Res. J. Pharm. Biol. Chem. Sci.,* 9(5):759-770.

Khan, Z.I., H. Safdar, K. Ahmad, K. Wajid, H. Bashir, I. Ugulu and Y. Dogan. 2019a. Health risk assessment through determining bioaccumulation of iron in forages grown in soil irrigated with city effluent. *Environ. Sci. Pollut. Res.,* 26(14): 14277-14286. https://doi.org/10.1007/s11356-019-04721-1.

Khan, Z.I., I. Ugulu, S. Sahira, K. Ahmad, A. Ashfaq, N. Mehmood and Y. Dogan. 2018b. Determination of toxic metals in fruits of *Abelmoschus esculentus* grown in contaminated soils with different irrigation sources by spectroscopic method. *Int. J. Environ. Res*., 12: 503-511.

Matemilola, S. and I. Elegbede. 2017. The challenges of food security in Nigeria. *Library J.,* 4: 1-22.

Mbah, C.N. and E.U. Onweremadu. 2009. Effect of organic and mineral fertilizer inputs on soil and maize grain yield in an acid Ultisol in Abakaliki-South Eastern Nigeria. *Amer. Eurasian J. Agron.,* 2: 7-12.

Mbatchou, V.C. and S. Dawda. 2013. The nutritional composition of four rice varieties grown and used in different food preparations in Kassena-Nankana district, Ghana. *Int. J. Res. Chem. Environ.,* 3(1): 308-315.

Milkha, S. and A. Aulakh. 2010. Integrated nutrient management for sustainable crop production, improving crop quality and soil health, and minimizing environmental pollution," presented at the 2010 19th World Congress of Soil Science, Soil Solutions for a Changing World 1–6 August 2010, Brisbane, Australia.

Mitchell, C.C. and S. Tu. 2005. Long term evaluation of poultry litter as a source of nitrogen for cotton and corn. *Agron. J.,* 97: 399-407.

Nadeem, M., T.M. Qureshi, I. Ugulu, M.N. Riaz, Q.U. An, Z.I. Khan, K. Ahmad, A. Ashfaq, H. Bashir and Y. Dogan. 2019. Mineral, vitamin and phenolic contents and sugar profiles of some prominent date palm (*Phoenix dactylifera*) varieties of Pakistan. *Pak. J. Bot.,* 51(1): 171-178.

Ning, Z.X., J.L. Zhang, M.J. Liu, F. Wu, C.Y. Huang and F.Q. Geng. 2014. Influence of different application amount of organic fertilizer on yield and quality of ecological tobacco. *Tianjin Agric. Sci.,* 20: 30-33.

Odedire, J.A. and O.J. Babayemi. 2008. Comparative studies on the yield and chemical composition of panicum maximum and andropogon gayanus as influenced by *Tephrosia candida* and *Leucaena leucocephala*. *Livest. Res. Rural Dev.,* 20: 1-8.

Pratap, D., J. Singh, R. Kumar, O. Kumar and K.S. Rawat. 2016. Effect micro-nutrients and farm yard manure on soil properties and yield of maize (*Zea mays* L.) in lower Indo Gangetic Plain of Uttar Pradesh. *J. Appl. Nat. Sci.,* 8(1): 236-239.

Qasim, M., J. Naheeda, Himayatullah and M. Subhan. 2001. Effect of sewage sludge on the growth of maize crop. *Online J. Biol. Sci.,* 1(2): 52-54.

Rafiq, M.A., A. Ali, M.A. Malik and M. Hussain. 2010. Effects of mulches and plant densities on yield and protein contents of autumn planted maize. *Pak. J. Agric. Sci.,* 47(3): 201-208.

Ramadan, M.A. and S.M. Adam. 2007. The effects of chicken manure and mineral fertilizers on distribution of heavy metals in soil and tomato organs, *Aust. J. Basic Appl. Sci.,* 1: 226-231.

Saeed, M., S. Ullah, Z. Shah, M. Iqbal, M. Waqas, M. Haroon and H.U. Shah. 2013. Proximate composition and mineral content of maize grains influenced by mulching. *Pak. J. Weed Sci. Res.,* 19(3): 349-355.

Sharma, V.K., S.K. Thakar, S.S. Vaish, M. Shafi and A.A. Mir. 2005. Effect of farm yard manure and phosphorus on growth and yield of spring wheat under cold arid region, Leh (Ladakh). *Agric. Sci. Dig.,* 25(3): 204-206.

Shayo, N.B., P. Mamiro, C.N.M. Nyaruhucha and T. Mamboleo. 2006. Physico-chemical and grain cooking characteristics of selected rice cultivars grown in Morogoro. *Tanzania J. Sci.,* 32(1): 29-36.

Steel, R.G.D., J.H. Torrie and D.A. Deekey. 1997. Principles and Procedures of Statistics: A Biometrical Approach. 3rd Ed. McGraw Hill Book Co. Inc. New York, pp. 400-428.

Thomas, R., W.A. Wan-Nadiah and R. Bhat. 2013. Physiochemical properties, proximate composition, and cooking qualities of locally grown and imported rice varieties marketed in Penang, Malaysia. *Int. Food Res. J.,* 20(3): 1345-1351.

Ugulu, I., S. Baslar, Y. Dogan and H. Aydin. 2009. The determination of colour intensity of *Rubia tinctorum* and *Chrozophora tinctoria* distributed in Western Anatolia. *Biotech. Biotechnol. Equip.,* 23 (SE): 410-413.

Ullah, I., A. Muhammad and F. Arifa. 2010. Chemical and nutritional properties of some maize (*Zea mays* L.) varieties grown in NWFP-Pakistan. *Pak. J. Nutr.,* 9(11): 1113-1117.

Unver, M.C., I. Ugulu, N. Durkan, S. Baslar and Y. Dogan. 2015. Heavy metal contents of *Malva sylvestris* sold as edible greens in the local markets of Izmir. *Ekoloji,* 24(96): 13-25. https://doi.org/10.5053/ekoloji.2015.01.

Wailare, A.T. and A. Kesarwani. 2017. Effect of integrated nutrient management on growth and yield parameters of maize (*Zea mays* L.) as well as soil physicochemical properties. *Biomed. J. Sci. Tech. Res.,* 1(2): 1-6.

Warren, J.G., S.B. Phillips, G.L. Mullins, D. Keahey and C.J. Penn. 2006. Environmental and production consequences of using alum amended poultry litter as a nutrient source for corn. *J. Environ. Qual.,* 35: 172-182.

Yossif, A.M. and Y.M. Ibrahim. 2013. Effect of organic and inorganic fertilizers on proximate analysis of Rhodes Grass (*Chloris gayana* L. Knuth.). *Univ. J. Plant Sci.,* 1(4): 137-140.

Zhao, Y., P. Wang, J. Li, Y. Chen, X. Ying and S. Liu. 2009. The effect 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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