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**ORIGINAL RESEARCH PAPER**

# Effects of long-term municipal waste compost application on the concentrations of macro elements and yield of rice

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**ABSTRACT**: An experiment was conducted as randomized complete block design with three replications and 14 fertilizer treatments in year 2014. The treatments were including the control, application of chemical fertilizers according the soil analysis, application of 15, 30 and 45 tons of municipal waste compost per ha as simple and with 25, 50 and 75% of chemical fertilizers. The results revealed that the 7 years using of municipal waste compost significantly increased the concentrations of nitrogen, phosphorus and potassium of the soils and rice grains and it improved the yield of rice as well. The highest concentrations of macro-nutrients (Nitrogen, Phosphorus and Potassium) were obtained in the treatment of 45 t/ha of municipal waste compost + 75% chemical fertilizers. The concentrations of nitrogen, phosphorus and potassium were increased 73.68, 230.0 and 30.74%, respectively, compared to the control treatment. Treatment of 45 t/ha + 25% of chemical fertilizer had the highest 1000 grains weight. The percentage of 1000 grains weight was increased 9.82 compared to the control treatment. The highest yield of pad was obtained by using of 45 tons + 25% of chemical fertilizers that compared to the control treatment showed 51.33% increase. Finally, from the results, it can be concluded that the combination of municipal waste compost and chemical fertilizers are reliable organic waste and fertilizers management strategy to increase the concentrations of macro-nutrients in rice and increase the rice yield as well.

**KEYWORDS:** *Chemical fertilizer; Grain yield; Macro-nutrient; Municipal waste compost (MWC); Rice*

## INTRODUCTION

In recent decays, large amount of municipal waste (MW), especially in populated areas, inevitably has moved and induced environmental pollution. The proper management strategy is necessary to avoid the pollution caused by the MW. The frequency used procedure to control the MW pollution is recycling and converting the MW to organic amendments. The practice of producing municipal waste compost (MWC) helps keep clean the environment. Furthermore, incorporation of MWC to agricultural land improves the soil nutrients concentrations (Khoshgoftarmanesh and Kalbasi, 2002).

The co-application of chemical and organic fertilizers is the suitable opportunity to improve soil nutrients and crops productivity (Nigussie *et al.*, 2015). Hargreaves *et al.* (2008) reported the MWC is a proper method to overt the wastage pollution and produce the low cast amendment for soil quality improvement. However, the single application of MWC to provide the nutrients for crops may not sufficient, hence, the adding of chemical fertilizers to MWC is helpful (Ramadass and Palaniyandi, 2007). Moreover, the single

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application of MWC may suppress the microbial activities of the soil since it has a high C/N ratio. In this case, the soil microbe competes with crops to uptake the N (Amlinger *et al.*, 2003). Again, this phenomenon indicated the adding chemical fertilizer such as N-chemical fertilizer to MWC is useful to crops growth. The co-application of MCW and chemical fertilizers to the wheat farm showed that dry weight, grain yield and the amount of N, P and K up taken by the crop increased (Bar-Tal *et al.*, 2004). The results of this study also showed that up taken P and K by crop grown in soil amended with compost was higher than crop grown in soil which received chemical fertilizer.

The MWC as amendment improved barbed chicory yield in both clayey and sandy soil (Papafilippaki *et al.*, 2015). Organic and chemical fertilizers are correlated to each other, and to create suitable conditions for plants' growth both types of fertilizers are needed (Roberts, 2008). The compost nutrients gradually and continuously become available in soil and to the plant, so its usefulness is more than one growing season, its nutrients' loss is less and reduced leaching of nutrients (Garling and Boehm, 2001). Gradual decomposition of organic matter increased the efficiency of nutrients and lasting effect of these compounds on plants' yield and soil properties for several years (Eghball *et al.*, 2004). The MWC in a short time provides available elements, stimulates microbial activity and in the long run preserves nutrients and organic matter (Bhattacharyya *et al.*, 2005). Also municipal waste compost enriched with chemical fertilizers in the farm increase availability of highly used elements by products and rise soil fertility and productivity (Ramadass and Palaniyandi, 2007). Using the MWC in agricultural lands has an important role in the sustainable production of crops (Olsen and Sommers, 1990). Diacono and Montemurro (2010) mentioned that long-term use of organic amendment induced proper yield. Cherif *et al*. (2009) reported that with five-year use of the MWC wheat grain yield increased. The addition of 30 and 45 t/ha of compost during 4 years had a higher yield than the control and 15 t/ha treatments (Morra *et al.*, 2010). Other studies showed that application of the MWC can increase the yield of crops and garden products and prevent harmful effects of waste landfill (Peyvast and Abbassi, 2006). However, the study regarding long term using of the MWC on yield and macro-nutrients up taken by rice is few. Therefore, the purpose of conducting this study was to study the effect of long-term (7 years) use of the MWC and chemical fertilizers on the concentrations of macro-nutrients (N, P and K) and the rice yield. This study has been carried out in research farm of Sari Agricultural Sciences and Natural Resources University (SANRU) within 7 years that started in 2008 and continued until 2014.

## MATERIALS AND METHODS

The experimental design was RCBD with three replications and fourteen treatments including:

1. Control (neither chemical nor organic fertilizers were used), 2. Application of chemical fertilizers according to the soil analysis (150 kg urea/ha, 100 kg triple superphosphate/ha and 100 kg potassium sulfate/ha), 3. 15 t MWC/ha, 4. 15 t MWC/ha + 25% chemical fertilizers, 5. 15 t MWC + 50% chemical fertilizers, 6. 15 t MWC + 75% chemical fertilizers, 7. 30 t MWC/ha, 8. 30 t MWC/ha + 25% chemical fertilizers, 9. 30 t MWC/ha + 50% chemical fertilizers, 10. 30 MWC/ha + 75% chemical fertilizers, 11. 45t MWC/ha, 12. 45t MWC/ha + 25% chemical fertilizers, 13. 45t MWC/ha + 50% chemical fertilizers, and 14. 45t MWC/ha + 75% chemical fertilizers.

Selected characteristics of MWC and the soil is shown in Table 1. Prior to running the experiment, soil sample was taken from the soil surface ( 0-30 cm) and its chemical and physical properties were determined. Soil pH and EC were measured (Rhoades, 1982). Soil

Table 1: Physical and chemical properties of the MWC and soil used

| Properties | Texture | EC (dS/m) | pH | OC (%) | N Available (%) | P Available (ppm) | K Available (ppm) |
|---|---|---|---|---|---|---|---|
| Soil | Silty clay | 2.09 | 7.70 | 2.00 | 0.19 | 12.20 | 230.0 |
| MWC* | - | 3.30 | 7.10 | 15.70 | 1.70 | 4200 | 7636.4 |

*MWC: municipal waste compost

organic carbon was determined according to method of Walkley-Black (Nelson and Sommers, 1982).

The rice cultivar was Tarom, which is one of the proper cultivar rice. The 35-day rice seedlings were translocated in 4-leaf stage with 25 cm distance from each other. The plots were 3×6 m.

After harvesting soil samples were taken from the depth of 0-30 cm, passed through sieve 2 mm. Total N concentration of soil was determined by Kjeldahl method (Westeman, 1990), the concentration of available P was determined by Olsen method (Olsen and Sommers, 1990) and available K concentration was measured according to Westeman method (Westeman, 1990). At harvesting stage of rice, samples of grains were taken. After preparation of plant samples, N concentration was measured by Kjeldahl method, the plant P concentration was measured by Olsen method and the plant K concentration was measured according Cottenine method (Cottenine *et al.*, 1982).

To determine the number of full seed, 1000 grains weight, spike length and plant height, 10 cluster were randomly selected from each plot were measured and desired traits. To calculate pod yield after rice processed 16 plants of each plot were harvested and after threshing grains were weighted under moisture 14%. The Statistix8.0 software was used to analyze data and the means were compared by LSD test.

## RESULTS AND DISCUSSION

*Soil*

The analysis of variance of MWC on macro-nutrients concentrations in soil showed that the effect of MWC on the macro-nutrients (Nitrogen, Phosphorus and Potassium) concentrations was significantly different at the probability level of 1% (Table 2).

The soil of 45 t MWC/ha + 75% chemical fertilizers treatment had a highest concentration of N. This treatment increased 73.68% soil N concentration compared to the control treatment. Of course, this treatment was not significantly different from other levels of 45 t MWC/ha, with and without other levels of chemical fertilizers. Also, by increasing rates of MWC, soil N concentration was increased so that in treatments 15, 30 and 45 t MWC/ha soil N concentration was increased .22, .25 and .29 %, respectively (Table 3). Many researchers stated using MWC for five consecutive years (Achebe *et al.*, 2009), four consecutive years (Ros *et al.*, 2006) and two consecutive years (Saha *et al*, 2007) increased the level of total soil N. That was due to the gradual release of N by long-term use of MWC (Erhart *et al.*, 2005). Total N in the soil was increased by using MWC compared to the control treatment. Given that MWC has high organic material it can be said increased soil N in treatments with compost was due to abundant organic matter (Giusquiani *et al.*, 1988). Adding organic wastes to the soil increased soil N (Tarrasón *et al.*, 2008).

The highest concentration of available P in the soil was related to treatment 45 t MWC/ha + 75% chemical fertilizer that compared to the control treatment showed 230% increase. Of course, this treatment was not significantly different from other levels of 45 t MWC/ha, and with and without other levels of chemical fertilizer. By increasing levels of MWC, concentration of available P in the soil was increased so that in treatments 15, 30 and 45 t MWC/ha available P concentration was 13.29, 19.02 and 29.09 mg/kg,

Table 2: Analysis of variance for the effect of the MWC on macro nutrients concentration in soil

| S.O.V* | df | Mean squares | | |
|---|---|---|---|---|
| | | N | P | K |
| Replication | 2 | 0.006$^{ns}$ | 19.636$^{ns}$ | 0.05723$^{ns}$ |
| Treatment | 13 | o.oo4$^{**}$ | 167.499$^{**}$ | 2.25230$^{**}$ |
| Error (SD) | 26 | 0.0008 | 6.758 | 0.59495 |
| CV*** (%) | - | 11.2 | 11.9 | 7.77 |

ns and** are non-significant and significant at 1% probability levels, respectively

*S.O.V: source of variance

***CV: coefficient of variance

respectively (Table 3). Increased amount of available P in the soil due to adding MWC during seven consecutive years is consistent with the findings of researchers (Mkhabela and Warman, 2005; Soumare *et al.*, 2003). P movement in the soil depends largely on biotic and abiotic conditions of the soil and enzymes responsible for P mineralization may be obtained from microorganisms in the soil, plants' root and sources of organic fertilizers (Saha *et al*, 2007). The use of organic fertilizers stabilizes P and increases microbial activity in the soil that finally resulted in increased availability of P for the plants (Borkar *et al.*, 1991). One of the reasons of increased solubility of P as a result of adding MWC, is the presence of high P in MWC and the formation of humic phosphate complexes which slow the process of phosphorus fixation in the soil (Giusquiani *et al.*, 1988; Laboski and Lamb, 2003).

As seen in Table 3, the highest amount of soil available K was related to treatment 45 t MWC/ha + 75% chemical fertilizer that compared to the control treatment showed 30.74% increase. Also a significant difference was found between the treatment and other treatments. Soil K concentration was increased when a small amount of MWC is used which was due to the absorption of available K in the compost (Hargreaves *et al.*, 2008). According to a report, K level in the soil using MWC enriched with chemical fertilizers was more than the control treatment and the use of MWC with chemical fertilizers in the soil showed the maximum amount of K to separate use of MWC (Ramadass and palaniyandi, 2007). In an experiment, by 5-year use of MWC soil available K on average showed 26% increase compared to the control treatment (Hartl *et al.*, 2003).

*The plant*

The results of analysis of variance showed that the effect of MWC on the concentration of some macro nutrients (N, P and K) had a significant difference in grains at the probability level of 1% (Table 4). The results of means comparison showed that the highest N concentration of grains was related to treatment 45 t MWC/ha + 75% chemical fertilizer that compared to the control treatment showed 16.83% increase. Of course, this treatment and treatments 45 and 30 t MWC/ha, with and without using chemical fertilizer as well as 15 t MWC/ha with using different levels of chemical fertilizer were at the same statistical level. By increasing MWC rates, soil N concentration was increased so that in treatments 15, 30 and 45 t MWC/ha N concentration was 2.01, 2.10 and 2.22, respectively (Fig. 1). Mineralized N in the compost is available for all the plant growth time, but N in chemical fertilizers due to high solubility and mobility will not be available for the latter stages of plant growth. On the other hand, compost mixed with chemical fertilizer can act as a source of N slow and immediate release and provide needed nitrogen for different growth periods of the plant (Mylavarapu and Zinati, 2009). In another study, treatment 19 tons per ha of textile MWC increased the amount of cowpea N accumulation at acceptable level compared to control (Araújo *et al.*, 2007).

Table 3: Mean comparison for the effect of MWC on macro elements concentration in soil

| Treatment | N (%) | P (mg/kg) | K (mg/kg) |
|---|---|---|---|
| control | $0.19^{f}$ | $9.97^{f}$ | $246.9^{d}$ |
| cf | $0.21^{ef}$ | $12.68^{ef}$ | $257.4^{bcd}$ |
| 15 tons mwc | $0.22^{def}$ | $13.29^{ef}$ | $257.4^{bcd}$ |
| 15 tons mwc + 25% cf | $0.24^{def}$ | $14.72^{df}$ | $274.8^{cd}$ |
| 15 tons mwc + 50% cf | $0.24^{def}$ | $18.59^{d}$ | $284.7^{bcd}$ |
| 15 tons mwc + 75% cf | $0.24^{def}$ | $18.91^{d}$ | $284.7^{bcd}$ |
| 30 tons mwc | $0.25^{cde}$ | $19.02^{d}$ | $303.3^{bc}$ |
| 30 tons mwc + 25% cf | $0.25^{cde}$ | $24.24^{c}$ | $303.9^{bc}$ |
| 30 tons mwc + 50% cf | $0.26^{bcd}$ | $25.84^{bc}$ | $313.2^{bc}$ |
| 30 tons mwc + 75% cf | $0.29^{abc}$ | $26.94^{bc}$ | $313.2^{bc}$ |
| 45 tons mwc | $0.29^{abc}$ | $29.09^{ab}$ | $313.2^{bc}$ |
| 45 tons mwc + 25% cf | $0.29^{abc}$ | $29.31^{ab}$ | $313.5^{bc}$ |
| 45 tons mwc + 50% cf | $0.30^{ab}$ | $30.17^{ab}$ | $313.8^{b}$ |
| 45 tons mwc + 75% cf | $0.33^{a}$ | $33.00^{a}$ | $322.8^{a}$ |

Means followed by the same letters at each column are not significant according to Duncan's multiple range test, at 5% difference level.
Cf: Chemical fertilizer;
MWC: Municipal waste compost

Table 4: Analysis of variance for the effect of MWC on macro elements concentration in grain

| S.O.V* | df | Mean squares | | |
|---|---|---|---|---|
| | | N | P | K |
| Replication | 2 | 0.005[ns] | 0.00006[ns] | 42.595[ns] |
| Treatment | 13 | o.o2** | 0.0016** | 181.377** |
| Error (SD) | 26 | 0.003 | 0.0001 | 14.723 |
| CV*** (%) | - | 2.6 | 7.3 | 11.6 |

ns and** are non-significant and significant at 1% probability levels, respectively
*S.O.V: source of variance
***CV: coefficient of variance

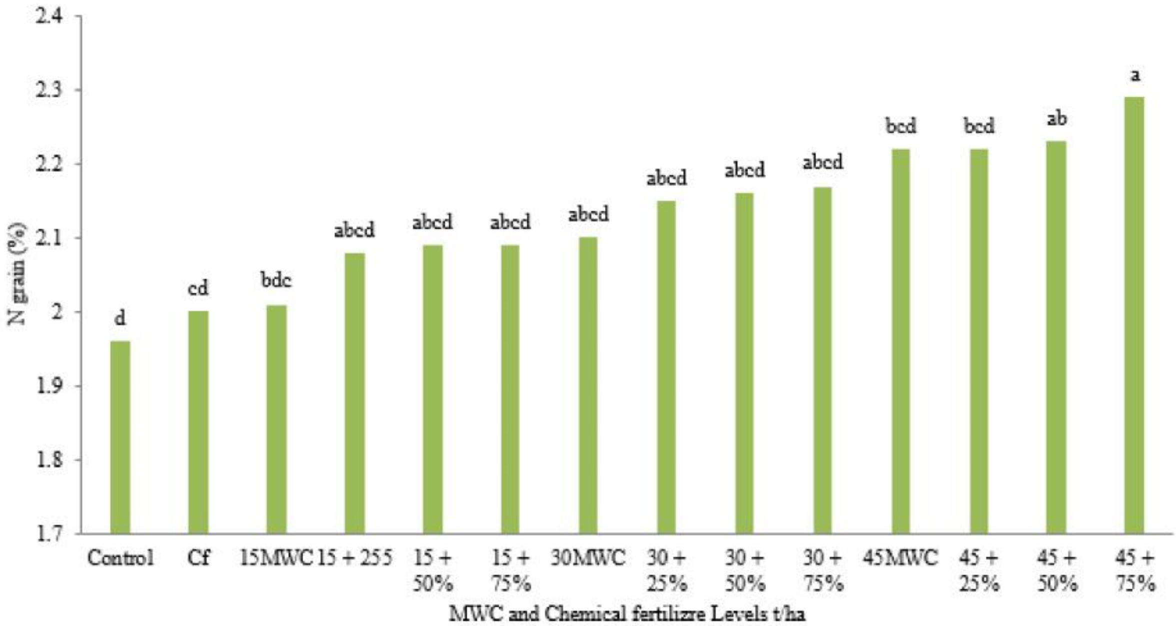


Fig. 1: Effect of municipal waste compost on N concentration in grain (%). MWC: municipal waste compost; Cf: chemical fertilizer; Means whit the same letters for each component have no significantly difference based on LSD test (P d" 0.05)

Fig. 2 shows that the highest concentration of P is related to treatment 45 t MWC/ha + 75% chemical fertilizer, which compared to the control treatment showed 61.90% increase. No significant difference was found between the treatment and treatment 45 t MWC/ha + 50% chemical fertilizer. The researchers found that the combination of MWC with chemical fertilizer containing N, P and K has increased P uptake percentage by plants. They stated that increased activity of microorganisms of solution of inorganic P in the soil and high concentration of this element in MWC were the main reasons of increased absorption of P due to using MWC (Mbaraki *et al.*, 2008; Soumare *et al.*, 2003). Many studies have shown that the use of organic matter in the soil increased available P to plants and indirectly prevented phosphate deposits as iron phosphate, aluminum phosphate and calcium phosphate as non-absorbable for plants (Tester, 1990). Examining the use of MWC and chemical fertilizer in wheat farm showed that dry weight, yield and the amount of N, P and K taken by grains increased by increasing the amount of MWC. Also the amount of available P and K in treatments with MWC was more than plants treated with chemical fertilizer (Bar-Tal *et al.*, 2004).

The highest amount of grains K is related to treatment of 45 t MWC/ha + 75% chemical fertilizer that compared to the control treatment showed 118% increase. A significant difference was found between the treatment and other treatments (Fig. 3). In a study, in order to investigate the effect of MWC on K uptake by rice plant it has been shown that due to the use of MWC the amount of K uptake by grains and shoots of the plant was increased (Bhattacharyya *et al.*, 2007). Frequently use of compost produced from municipal waste had a significant effect on the amount of leaf K and totally compost fertilizer provided the plant essential nutrients (Warman *et al.*, 2009). Increased grain yield in relation to the use of MWC can be due to improved

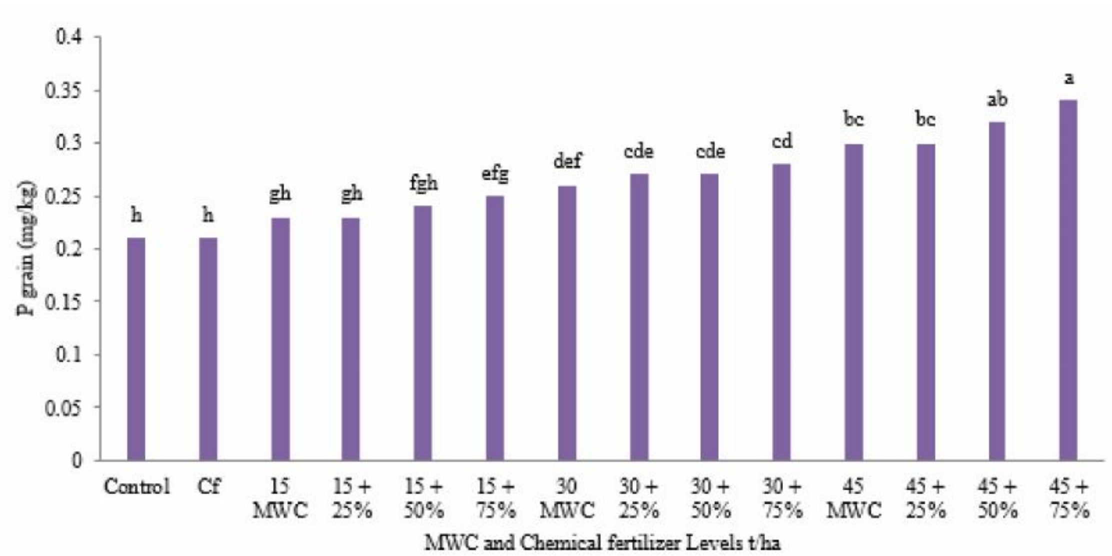


Fig. 2: Effect of municipal waste compost on P concentration in grain (mg/kg). MWC: municipal waste compost; Cf: chemical fertilizer; Means whit the same letters for each component have no significantly difference based on LSD test (P d" 0.05)

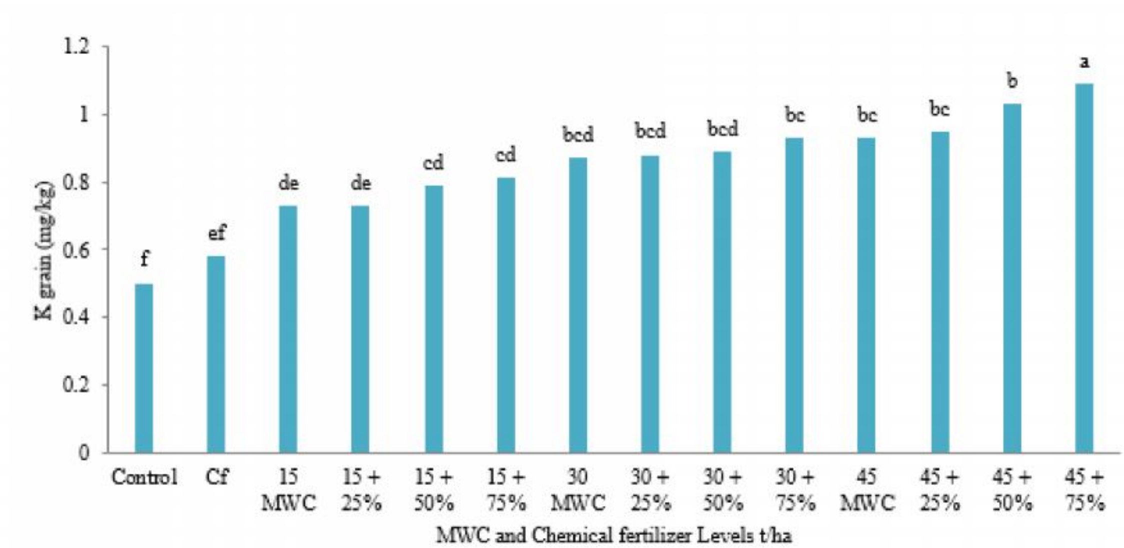


Fig. 3: Effect of municipal waste compost on K concentration in grain (mg/kg). MWC: municipal waste compost; Cf: chemical fertilizer; Means whit the same letters for each component have no significantly difference based on LSD test (P d" 0.05)

soil organic matter, increased usability of N, P, K and reduced pH in the soil (Aggelides and Londra, 2000). In an experiment, using 50, 100, 150, 200 and 250 kg per hectare MWC the results showed that treatment of 250 kg per hectare had the highest amount of N, P and K (Mishra *et al.*, 2009).

*Yield*

The results of analysis of variance showed that the effect of MWC on the plant height, spike length, 1000 grains' weight, the number of grains per raceme and pod yield were significant at 1% level (Table 5).

The results of mean comparison showed, the highest plant height is related to treatment 45 t MWC/ha that compared to the control treatment showed 20.36% increase. No significant difference was found between the treatment and treatment 45 t MWC/ha with 25% of fertilizer, also a significant difference was found between the two treatments and other treatments (Table 6). The researchers reported that the use of different levels of compost had a significant effect on mung and sunflower height, and during 10 years the effect of compost on plant growth is gradually increased (Sivakumar *et al.*, 2000; Erhart *et al.*, 2005). According to Table 6, the maximum spike length is related to treatment 45 t MWC/ha with 25% fertilizer that compared to the control treatment showed 29.73% increase and a significant difference was found between the treatment and other treatments. Peng *et al.* (2002) stated that dry matter accumulation by selecting large cluster increasing the reservoir size (the number of grains per unit of surface) will be doubled. In terms of 1000 grains' weight, treatment 45 t MWC/ha with 25% fertilizer compared to the control treatment showed 9.82% increase so that a significant difference was found between this treatment and all other treatments (Table 6). Factors affecting grains' yield in yielding and hybrid cultivars are the range of root system growth, the growth rate in the growth stage, the productivity of the reservoir and its size, the amount of carbohydrates' transfer from the plant growth parts to spike lenght and leaf area index of the plant during grains' filling period (yang *et al.*, 2003). Treatment 45 tons of compost + 50 percent fertilizer had the highest number of grains per raceme that compared to the control treatment showed 14.17% increase, so that no significant difference was found between this treatment and treatment 45 tons of compost + 75% fertilizer (Table 6). If the size of the reservoir is increased grains' filling should be improved, increased duration of grains' filling and optimized spike length morphological properties increased full grains' percentage, for this purpose the performance of photosynthetic and stored matter transfer should be improved. The amount of transfer and the ability of spikelet to accept carbohydrates are increased. Reservoir size can be increased by increasing spike length size and reducing the number of ineffective claw, strong stem and sound leaf (Peng *et al.*, 2002). The highest pod yield is related to treatment 45 t MWC/ha + 25% fertilizer that compared to the control treatment showed 51.13% increase. A significant difference was found between the treatment and all other treatments (Table 6). In a study, treatment

Table5: Analysis of variance for the effect of MWC on yield components and yield of grain

| S.O.V | df | Mean squares | | | | |
|---|---|---|---|---|---|---|
| | | Plant height | Spike length | 1000-grain weight | No. of grain in cluster | Grain yield |
| Replication | 2 | $0.93^{ns}$ | $0.76^{ns}$ | $0.004^{ns}$ | $0.21^{ns}$ | $2.2^{ns}$ |
| Treatment | 13 | $77.34^{**}$ | $11.77^{**}$ | $0.83^{**}$ | $94.07^{**}$ | $10701.9^{**}$ |
| Error (SD) | 26 | 2.71 | 0.24 | 0.01 | 2.08 | 0.9 |
| CV (%) | - | 1.44 | 1.74 | 0.39 | 1.07 | 0.18 |

ns and** are non-significant and significant at 1% probability levels, respectively

S.O.V: source of variance CV: coefficient of variance

75 percent mineral fertilizer + 25 percent of N in terms of yield showed better performance than other treatments (Kavitha and Subramanian, 2007). Lima *et al.* (2004) by the use of compost stated that compost increased the yield of corn. High level of yield in the soil treated with organic fertilizers compared to control was due to appropriate supply of nutrients needed by plants as well as improving soil physical conditions due to the favorable effect of organic matter (Weber *et al.,* 2007).

The seven-year use of MWC increased the concentration of nutrients in the soil and grain as well as rice plant yield. The highest concentration of soil available K is related to treatment of 45 t MWC/ha+75% chemical fertilizer. For soil N and P, 45 tons of MWC with and without chemical fertilizer had the best conditions and it can be concluded in the case of several-year use of 45 t MWC/ha, only K chemical fertilizer is needed and practically there is no need to use P and N chemical fertilizers. By increasing rates of MWC, the concentration of macronutrients was increased in the soil and rice plant. Also the use of MWC had a significant effect on the concentration of macronutrients in the rice plant grain and yield. In the case of grain N, the use of 45 t MWC/ha + 75% chemical fertilizer was significantly different from control, chemical fertilizer and 15 t MWC/ha treatments. The highest concentration of grain P was related to treatment 45 t MWC/ha + 50% and 75% chemical fertilizer. Also the highest concentration of grain K was obtained in

Table 6: Mean comparison for the effect of MWC on yield components and yield of grain

| Treatment | Plant height (cm) | Cluster length (cm) | 1000-grain weight (gr) | No. of grain in cluster | Grain yield (kg/ha) |
|---|---|---|---|---|---|
| control | 101.7$^{g}$ | 25.59$^{h}$ | 24.53$^{h}$ | 127$^{g}$ | 4050.6$^{l}$ |
| cf | 109.35$^{f}$ | 26.41$^{gh}$ | 25.51$^{g}$ | 128.3$^{fg}$ | 4530$^{k}$ |
| 15 tons mwc | 112.2$^{e}$ | 26.91$^{g}$ | 25.62$^{g}$ | 129.3$^{fg}$ | 4530.3$^{k}$ |
| 15 tons mwc + 25% cf | 112.41$^{e}$ | 26.97$^{g}$ | 25.67$^{fg}$ | 129.6$^{f}$ | 4820.3$^{j}$ |
| 15 tons mwc + 50% cf | 112.60$^{e}$ | 27.17$^{fg}$ | 25.79$^{ef}$ | 129.6$^{f}$ | 4930.3$^{i}$ |
| 15 tons mwc + 75% cf | 113.19$^{de}$ | 28.03$^{ef}$ | 25.8$^{ef}$ | 133.3$^{e}$ | 5000.3$^{h}$ |
| 30 tons mwc | 115.46$^{cd}$ | 28.07$^{e}$ | 25.85$^{e}$ | 134.3$^{de}$ | 5300$^{g}$ |
| 30 tons mwc + 25% cf | 115.46$^{cd}$ | 28.56$^{de}$ | 25.92$^{de}$ | 135$^{cde}$ | 5300$^{g}$ |
| 30 tons mwc + 50% cf | 117.05$^{c}$ | 28.76$^{de}$ | 25.92$^{de}$ | 136$^{cd}$ | 4560.3$^{f}$ |
| 30 tons mwc + 75% cf | 117.3$^{c}$ | 28.91$^{cd}$ | 26.18$^{c}$ | 137$^{bc}$ | 5490.6$^{e}$ |
| 45 tons mwc | 122.41$^{a}$ | 29.72$^{bc}$ | 26.41$^{b}$ | 137$^{bc}$ | 6000$^{b}$ |
| 45 tons mwc + 25% cf | 120.14$^{ab}$ | 33.2$^{a}$ | 26.94$^{a}$ | 144$^{a}$ | 6130$^{a}$ |
| 45 tons mwc + 50% cf | 117.46$^{bc}$ | 30.54$^{b}$ | 26.03$^{cd}$ | 145$^{a}$ | 5780.6$^{c}$ |
| 45 tons mwc + 75% cf | 117.34$^{c}$ | 30.26$^{b}$ | 25.96$^{de}$ | 139.3$^{b}$ | 5600$^{d}$ |

Means followed by the same letters at each column are not significant according to Duncan's multiple range test, at 5% difference level. Cf: Chemical fertilizer; MWC: Municipal waste compost treatment 45 t MWC/ha + 75% chemical fertilizer. In total, consumption of MWC increased nutrients' concentration and yield of rice plant and minimized the need to use chemical fertilizers.

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## CONFLICT OF INTEREST

There is no conflicts of interest for publication of the manuscript.

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