African Journal of Agricultural Research Vol. 3 (9), pp. 633-639, September 2008
Available online at http://www.academicjournals.org/AJAR
ISSN 1991-637X © 2008 Academic Journals

*Full Length Research Paper*

# Effects of compost and green manure of pea and their combinations with chicken manure and rapeseed oil residue on soil fertility and nutrient uptake in wheat-rice cropping system

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Accepted 3 August, 2008

**Farmers use huge chemical fertilizers for cereal production, which causes health and environmental hazards. Adoption of legumes in cereal based cropping systems and improvement of organic fertilizers are needed to reduce chemical fertilizer use. Pot experiments were carried out with compost and green manure of pea plant residue with dried chicken manure and/or rapeseed oil residue to find out effects of compost and green manure on soil fertility and nutrient uptake by wheat and rice. Pea residue was mixed with chicken manure or rapeseed oil residue or half of chicken manure plus rapeseed residue or nothing was mixed for composting and green manuring for wheat. We also examined the residual effects of the fertilizers on rice. Composts of pea residue with chicken manure and chicken manure plus rapeseed residue enriched soil with N, P, K and other nutrients, and increased nutrient accumulation. Higher values were found for compost than for green manure but green manure with rapeseed residue also supplied higher residual nutrients and improved uptake and yield components. Rapeseed residue released nutrients slowly but chicken manure was efficient and stimulated the former when they were mixed. Pea compost with chicken manure or chicken manure plus rapeseed oil residue is recommended to improve soil fertility for wheat and rice.**

**Key words:** Chicken manure, compost, green manure, rapeseed oil residue, soil fertility improvement.

## INTRODUCTION

Use of chemical fertilizers has increased worldwide for cereal production (Abril et al., 2007) due to availability of inexpensive fertilizers (Graham and Vance, 2000). The continued use of chemical fertilizers causes health and environmental hazards (Pimentel, 1996). Expansion of area and intensification of rice-wheat production systems to support green revolution have also resulted physical and chemical deterioration of the soil since 1960's (Gupta et al., 2003). Possible options to reduce chemical fertilizer use could be adoption of leguminous crops in cereal based cropping systems and recycling of organic wastes. Rotation of legumes in cereal based cropping system reduces dependence on chemical fertilizer (Patil et al., 2001) and improves soil conditions (Rochester et al., 2001). Use of organic wastes in agriculture is well known but the idea is not widely accepted due to some limitations. For example, researchers advise farmers to use Sesbania as green manure (GM) in cereal based cropping systems but farmers do not respond spontaneously due to "no direct financial return". There should be one crop in the cropping system which can give direct income plus scope to recycle plant nutrients for cereals.

Additionally, recycling of indigenous agricultural wastes should be done properly i.e. wastes should be recycled as GM or compost to achieve highest nutrient recovery. Between the two, compost would be better than GM because, compost handling is less dangerous than raw material handling in terms of ammonia volatilization and leaching of N and P (Arja and Maritta, 1997).

Effective use of organic wastes is an important issue in developing countries. Poultry industry is now booming in these countries; where, it discharges huge amount of

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**Table 1.** Physical and chemical properties of soil, after cultivation of pea but before addition of compost and green manure as well as before wheat sowing.

| Sand | Silt | Clay | PD[a] | pH | EC[b] | Total N | Total C | C/N | P | K | Ca | Mg | Na |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (%) | | | | ($H_2O$) | | (g kg $^{-1}$) | | | (mg kg $^{-1}$) | | | | |
| 52.4 | 30.3 | 17.3 | 2.52 | 6.41 | 0.26 | 1.3 | 8.8 | 6.77 | 82.7 | 130 | 900 | 224 | 38 |

Source: Ph.D. thesis (2008), Gifu University, Japan.
[a]Particle density (g cm$^{-3}$); [b]Electrical conductivity (mS cm$^{-1}$).

**Table 2.** Properties of green pea plant residue (PP), dried chicken manure (CM) and rapeseed oil residue (RR), which were measured on dry weight basis.

| Characteristic | PP | CM | RR |
|---|---|---|---|
| pH ($H_2O$) | 7.81 | 6.30 | 5.65 |
| EC (mS cm$^{-1}$) | 5.90 | 6.22 | 3.27 |
| TN (g kg $^{-1}$) | 25.30 | 42.70 | 66.60 |
| TC (g kg $^{-1}$) | 395.50 | 372.90 | 428.50 |
| C/N | 15.63 | 8.73 | 6.43 |
| P (g kg $^{-1}$) | 2.87 | 4.53 | 19.90 |
| K (g kg $^{-1}$) | 20.61 | 20.66 | 18.67 |
| Ca (g kg $^{-1}$) | 10.50 | 0.25 | 1.04 |
| Mg (g kg $^{-1}$) | 3.00 | 0.23 | 0.33 |
| Na (g kg $^{-1}$) | 0.33 | 0.50 | 0.48 |
| Volatile solid (%) | 87.40 | 84.60 | 76.40 |

Source: Ph.D. thesis (2008), Gifu University, Japan.

poultry manure, which pollutes the environment (Sharpe et al., 2004). The manure contains important nutrients such as N, P, K, organic matter, Ca, Mg, etc. (Abdelhamid et al., 2004). Rapeseed (*Brassica napus L.*) production has been increasing worldwide (Zaller et al., 2008) and its residue contains the above nutrients at much higher concentration than chicken manure (Abdelhamid et al., 2004). Use of such organic materials in agriculture may contribute to preserve the environment as well as improve farmland fertility.

Wheat and rice are cultivated in many countries as staple foods but adoption of legume crops in the system is not popular in many countries. Some farmers in developing countries cultivate peas in their homestead gardens and get financial benefit from it after selling the peas. However, the crop residues are thereafter burnt. Burning of residue reduces N, P, K and S by up to 80% (Raison, 1979), 25 and 21% (Ponnamperuma, 1984) and 4 - 60% (Lefroy et al., 1994), respectively, which could be recycled in the system. Burning also causes atmospheric pollution (Samar et al., 1999) and harms beneficial soil organisms (Kumar and Goh, 2002). If pea (*Pisum sativum L.*) is incorporated in cereal based system and nutrient supplying ability of pea residue is improved then it might be accepted by the farmers as one option to increase their income and thereby improve soil fertility. In our previous experiment (Eusuf Zai et al., 2008), we found higher wheat grains for fertilization with dried chicken manure (CM) and CM plus rapeseed oil residue (RR) supplemented pea composts. It may happen due to improvement of soil fertility by the composts. Moreover, residual effects of the composts could be evaluated for justifying the efficiency. Thus, the present investigation has been initiated to evaluate the effectiveness of compost and GM of green pea plant residue (PP) with CM and/or RR on soil fertility and growth of wheat and rice.

## MATERIALS AND METHODS

### Cultivation of pea

Pea (cv. Akabana Tsuruari Kinusaya Endo) was grown on Wagner 1/2000a pot (0.05 m$^2$ area) having air-dried and sieved a brown lowland sandy loam soil. The soil was enriched with a commercial compost (N = 4%, P = 3% and K = 2%) by applying at the rate of 20 g pot$^{-1}$. Pea seeds were sown on 28 November 2004. Pea was cultivated for the plant residues (after pod harvest) to prepare treatment combination (composting and green manuring) to grow wheat of pea-wheat-rice cycle, which ultimately supplied residual nutrients to rice. Pea was grown in a green house of the Faculty of Applied Biological Science, Gifu University, Japan (35°27′N, 136°46′E). Five seeds were sown and after emergence 3 good seedlings were kept in each pot. Irrigation was done several times with tap water. The soil was collected from the Nagara River near Gifu University and average data of characteristics of the soil after pea cultivation are shown in Table 1. Due to severe cold; flowering was late and started from 2nd week of March whilst pods were harvested on mid to last week of April 2005 from all 3 plants of every pot. On an average 10 pods were harvested from every plant, which was 4.5 g each with small and immature seeds. Approximately 0.4 g N was fixed by pea plants in each pot (Rochester et al., 2001), which was estimated by subtracting the removed N (by pea plants) from received N by each pot (through soil and commercial compost) which was compared with the remaining N at the end of pea cultivation. Properties of PP, CM and RR are shown in Table 2.

### Composting and green manuring

After young pod harvest, pea plant residues were cut into 3 - 5 cm pieces, weighed and put either in empty pots (Wagner, 2000a) for making compost or kept in pot soils (where pea was grown) directly as GM. One hundred fifty gram PP were kept in every pot other than the control and 30 g CM or 30 g RR or 15 g CM plus 15 g RR were mixed with it or nothing was mixed. One hundred fifty gram PP means 3 plants of each pot (contribute approximately 230 kg N ha$^{-1}$ on dry weight basis) were mixed with soil of each pot as GM or mixed after composting, thus farmers can use all PP in their field.

**Table 3.** Treatment combinations compiled by green pea plant residue (PP), dried chicken manure (CM) and rapeseed oil residue (RR) for wheat.

| Treatments | Abbreviation |
|---|---|
| **Composting** | |
| 150 g PP | TC1 |
| 150 g PP + 30 g CM | TC2 |
| 150 g PP + 30 g RR | TC3 |
| 150 g PP + 15 g CM + 15 g RR | TC4 |
| **Green manuring** | |
| 150 g PP | TG1 |
| 150 g PP + 30 g CM | TG2 |
| 150 g PP + 30 g RR | TG3 |
| 150 g PP + 15 g CM + 15 g RR | TG4 |
| Control (native nutrients only) | T0 |

The treatments were also same for rice cultivation where they supplied residual nutrients.

Chicken manure was collected from Oku Mikawa chicken farm, near Gifu, Japan and RR was collected from local market. Organic materials were put in empty pot for making compost, mixed thoroughly and covered with lid but not airtight. Moisture content was kept at 60% by frequent checks using Hydrosense moisture meter (Campbell Scientific Inc., USA) throughout the decomposition period (Liang et al., 2003). Composting materials were turned at a fortnight interval. Simultaneously green manuring materials were also mixed with soil at the same time of initiation of composting. Although composts were matured by 100 days but they were not mixed with soil until the beginning of wheat season. Composts were mixed with the pot soils (where pea was grown) at 3 weeks before wheat sowing but the pots belonged to GM treatments at that time contained the similar organic materials like compost.

#### Soil collection

Soil samples were collected from pot soils before application of compost and GM materials, and 3 weeks after application of compost. At the same time soil was also collected from GM treatments. Samples were collected from 0 - 15 and 15 - 30 cm depth by auger and mixed together. Soil samples were again collected after wheat that is, before rice cultivation.

#### Cultivation of wheat on compost and GM treated soil

Winter wheat (*Triticum aestivum* var. Norin 61) was sown on 2 November 2005 in pot having 12 kg soil, where pea was grown but the soil was enriched with compost and GM. Wheat was grown in the same green house as the pea. Five seeds were sown and after emergence three good seedlings were kept in each pot. Among the 9 treatments, 4 were composts and 4 were green manures and the remaining one was control (native nutrient only). Treatments were replicated 4 times. Treatment combinations are presented in Table 3. For measuring nutrient content and weight of shoot, plants were cut at ground level at tillering stage. After collection, shoots were oven-dried before measuring nutrient content and shoot weight. The pots were kept weed free and wheat was irrigated by tap water. There was no pest infestation.

#### Cultivation of rice with residual nutrients

Rice (*Oryza sativa* cv. Hatsushimo) was initially sown on Rock wool on 18 May 2006 and 3 (month-old) seedlings were transplanted in each pot (where wheat was grown) on 20 June 2006. The experiment was also conducted with natural light in the same green house where wheat was grown. The treatments were the same as those of wheat i.e. 9 treatments with 4 replications. No nutrient was added to rice soil but it was cultivated amid residual effects of previously applied nutrients. For measuring nutrient content and weight of shoot, plants were cut at ground level at booting stage. After collection, shoots were oven-dried before measuring nutrient content and shoot weight. Plants were irrigated several times with tap water to maintain flooded condition. Plants were free from pest and disease. Statistical calculations were carried out using statistical techniques (Excel statistical package version 6) appropriate for completely randomized design. All data were analyzed by analysis of variance (ANOVA) and the treatment means were compared at 5% level of significance using Duncan's Multiple Range test.

#### Chemical and physical analyses

Soil, organic materials and plant shoot were air-dried first and then oven-dried at 70°C for 72 h, and ground to pass 0.5 mm sieve for chemical analysis. The pH and electrical conductivity (EC) were determined by the methods described by Jackson (1973) and Kalra and Maynard (1994), respectively. EC and pH were measured in the aqueous extracts of PP, CM and RR in a solid: distilled water ratio of 1:20 (w/v dry weight basis). EC and pH of soil were measured in 1:2.5 mixture of soil and distilled water. EC was determined by using a conductivity meter (CM-25R) and pH using a HORIBA (F-14) pH meter. Total N and C were measured using a CN analyzer, Sumigraph NC-95A of Shimadzu Corporation, Japan. The exchangeable cations ($K^+$, $Ca^{2+}$, $Mg^{2+}$ and $Na^+$) were extracted using 1 M-ammonium acetate (Thomas, 1982) and the extracts were analyzed by a Polarized Zeeman Atomic Absorption Spectrophotometer (HITACHI 180 - 60). Phosphorus was determined colorimetrically (HITACHI U-1000) according to Bray and Kurtz (1945). Particle density of soil was determined by pycnometer (Blake and Hartge, 1986). Volatile solid was measured as the gravimetric loss-on-ignition produced by ashing the samples (previously oven-dried) in a muffle furnace for 6 h at 600°C.

## RESULTS AND DISCUSSION

### Nutrient dynamics and response of wheat

Nitrogen (N), phosphorus (P), potassium (K) and calcium (Ca) contents of soil and plant tissue are presented in Table 4. Experimental results revealed that there were variations among different treatments in terms of nutrient content of soil and plant tissue. Total nitrogen contents of soil were significantly higher in the treatments where CM and RR supplemented compost (TC4) and only CM supplemented compost (TC2) were applied. Wheat plants also accumulated significantly higher N from the treatments. Plants grown with only RR supplemented compost (TC3) and GM (TG3) should provide the soil and plant with higher quantity of N than all treatments, because RR contains higher N than CM and PP, but practically it did not happen. This may be due to slow nutrient releasing nature of RR (Table 2 and 4). Although having less N in the source materials, TC2 and TC4 performed well may be due to CM, appropriate decomposition of composting materials and mineralization of N ( Eusuf Zai et al., 2008).

**Table 4.** Effects of compost and green manure on nutrient content (g $kg^{-1}$) of initial soil of wheat and wheat shoot.

| Treatments | Nitrogen | | Phosphorus | | Potassium | | Calcium | |
|---|---|---|---|---|---|---|---|---|
| | Soil | Shoot | Soil | Shoot | Soil | Shoot | Soil | Shoot |
| TC1 | 2.518c | 27.02b | 0.143c | 0.583b | 0.231b | 20.97b | 1.044g | 4.42bc |
| TC2 | 2.811a | 28.80a | 0.180a | 0.667a | 0.245a | 22.90a | 1.689a | 4.46a |
| TC3 | 2.667b | 26.99b | 0.166b | 0.584b | 0.227b | 20.79b | 1.313e | 4.41bc |
| TC4 | 2.848a | 28.93a | 0.177a | 0.663a | 0.249a | 22.92a | 1.547c | 4.47a |
| TG1 | 1.952e | 24.81c | 0.137c | 0.520d | 0.165e | 19.18c | 1.185f | 4.20d |
| TG2 | 1.981e | 27.21b | 0.129d | 0.537c | 0.177d | 18.47d | 1.597b | 4.45a |
| TG3 | 2.103d | 26.94b | 0.161b | 0.444e | 0.170e | 17.86e | 1.527c | 4.40c |
| TG4 | 2.057d | 27.25b | 0.140c | 0.520d | 0.199c | 18.07e | 1.421d | 4.43b |
| T0 | 1.300f | 18.12d | 0.083e | 0.400f | 0.132f | 17.02f | 0.900h | 3.75e |

Means followed by the same letter within a column are not statistically different according to Duncan's test at P<0.05.

Jeyabal and Kuppuswamy (2001) found higher yield due to higher mineralization and nutrient uptake by enhanced microbial population in rice-legume cropping system. Nitrogen contents of TC2 and TC4 composts were also increased due to N fixing bacteria (Wong et al., 2001). Moreover, mineralization rate is the greatest in poultry litter (Bowden et al., 2007) and the readily available N (ammonium-N+uric acid-N) in poultry manure can supply 30-50% of the total N to plants (Nicholson et al., 1996). On the other hand, higher the N in fertilizer source, higher the N harvest by plant (Oscarson, 2000), was not true in our experiment due to RR. Zmora-Nahum et al. (2007) observed that plants grown on oilcake exhibited low fresh weight due to unique chemical composition of the oilcake, which slows its degradation and nutrient release. Although TC4 was a combination of CM and RR with PP but in TC4, CM itself was efficient and mitigated slow releasing character of RR. So, pea composts with CM and CM plus RR could be effective for N supply to subsequent wheat crop.

Phosphorus and K contents of soil were also significantly higher where soil received TC4 and TC2 composts. Naturally plants were able to accumulate higher amount of P and K from the composts thus contents of the nutrients were significantly higher in plants. Phosphorus level of soil and plant tissue should be higher in the treatment having higher amount of RR, because it contains higher amount of P than CM and PP (Table 2). Phosphorus release from RR might be slow thus TC3 and TG3 were not the best. According to Hirzel et al. (2007), P recovery from CM is even higher than inorganic fertilizer, in spite of having comparatively less P in it (Tewari et al., 2007). According to Eusuf Zai et al. (2008), microbial activity is higher in CM associated soil which helps to release P from soil and increases plant uptake. So, P contents of plant tissue were significantly higher in TC2 and TC4 (Zaidi et al., 2003). Potassium harvest is also positively related to P harvest, may be due to enhanced root proliferation by P. According to Abdelhamid et al. (2004), CM and RR enriched compost of rice straw improves soil chemical, physical and biological properties and the compost is effective without chemical fertilizer. Calcium content of soil was significantly higher where CM supplemented compost was applied and Ca contents of wheat tissue were significantly higher in TC2, TC4 and TG2. This may be attributed to easy availability of Ca from CM.

Table 5 shows that magnesium (Mg) content of soil was significantly higher where soil received TC2 compost but the content of Mg in wheat shoot was significantly higher where plant received Mg from TC4. Carbon content of soil was higher when soil was enriched with the composts with CM and/or RR. When TC2 compost was applied into the soil then the concentration of Na was significantly higher than in all other treatments (Table 5). Moreover, the quantity of Na is within acceptable range as the tolerance level of exchangeable sodium is 0 - 5% (Lichthardt and Jacobsen, 1991). TC4 treated soil had less and safe amount of Na. There were no massive variations of pH among the treatments but TG3 exhibited significantly higher pH. Due to higher content of Na in the TC2 treatment, the soil showed significantly higher EC. Significantly higher shoot dry matter was produced due to sufficient uptake of N, P and K from TC2 and TC4. Although RR contains higher nutrients but it did not perform well for the first crop but it could contribute for the next crop as slow releasing fertilizer.

## Nutrient dynamics and response of rice

Nitrogen, P and K contents of soil (before transplantation) and shoot of rice are presented in Table 6. Significantly higher contents of N, P and K were obtained in the soil of TC2 and TC4 among compost treatments and TG3 among green manures. Rice plants accumulated significantly higher amount of N, P and K from the treatments and as a result the concentrations of the nutrient elements were significantly higher in the plant tissue. Recovery efficiency of N from CM is higher due to larger residual effect and less leaching of N (Hirzel et al., 2007).

**Table 5**. Effects of compost and green manure on nutrient content and properties of initial soil of wheat, nutrient content and weight of wheat shoot.

| Treatments | Magnesium | | Carbon | Sodium | pH | EC | DWS |
|---|---|---|---|---|---|---|---|
| | (g kg$^{-1}$) | | | | ($H_2O$) | (mS cm$^{-1}$) | (g hill$^{-1}$) |
| | Soil | Shoot | Soil | Soil | Soil | Soil | |
| TC1 | 0.337d | 3.95b | 15.525b | 0.049c | 5.74h | 0.81c | 11.08b |
| TC2 | 0.547a | 4.00b | 18.800a | 0.070a | 7.09b | 1.48a | 14.98a |
| TC3 | 0.512b | 3.95b | 19.175a | 0.061b | 6.32g | 1.29b | 12.11b |
| TC4 | 0.498c | 4.28a | 18.825a | 0.041d | 6.89d | 0.78cd | 15.22a |
| TG1 | 0.319e | 3.78c | 9.750e | 0.037f | 6.57e | 0.73de | 10.71b |
| TG2 | 0.335d | 3.99b | 11.101d | 0.035g | 6.95c | 0.53f | 11.02b |
| TG3 | 0.313e | 3.92b | 11.853c | 0.033h | 7.19a | 0.68e | 10.71b |
| TG4 | 0.285f | 3.99b | 9.600e | 0.032i | 6.96c | 0.50f | 11.06b |
| T0 | 0.224g | 3.61d | 8.880f | 0.038e | 6.41f | 0.26g | 3.43c |

DWS: Dry weight of shoot; Means followed by the same letter within a column are not statistically different according to Duncan's test at P<0.05.

**Table 6.** Effects of compost and green manure on nutrient content (g kg$^{-1}$) of rice shoot and soil before transplantation of rice.

| Treatments | Nitrogen | | Phosphorus | | Potassium | |
|---|---|---|---|---|---|---|
| | Soil | Shoot | Soil | Shoot | Soil | Shoot |
| TC1 | 1.453b | 7.07bc | 0.123cd | 1.09b | 0.171d | 16.83b |
| TC2 | 1.574a | 8.71a | 0.162a | 1.15a | 0.231a | 18.17a |
| TC3 | 1.350bc | 7.43b | 0.125c | 1.09b | 0.200b | 16.03c |
| TC4 | 1.577a | 8.72a | 0.162a | 1.18a | 0.230a | 18.36a |
| TG1 | 1.091e | 6.51d | 0.120e | 0.93d | 0.162e | 14.35d |
| TG2 | 1.257cd | 6.88c | 0.121de | 1.07bc | 0.181c | 16.30bc |
| TG3 | 1.578a | 8.47a | 0.160a | 1.15a | 0.231a | 18.35a |
| TG4 | 1.225d | 6.96c | 0.129b | 1.04c | 0.205b | 16.01c |
| T0 | 1.052e | 6.31d | 0.107f | 0.80e | 0.086f | 13.99d |

Means followed by the same letter within a column are not statistically different according to Duncan's test at P<0.05.

Initially TG3 treatment received higher amounts of nutrients than all other treatments but probably due to unfavorable soil condition and slow releasing nature of RR, TG3 did not perform well during wheat cultivation. With time, RR might have decomposed and nutrients were released from it at the second cropping season. Although TC3 did not show the best performance in nutrient supply to soil, it supplied good amounts of nutrients from the beginning may be due to better decomposition during composting process when compared to GM. Potassium content of initial soil of rice was a bit lower than the initial soil of wheat, even after removal of some K by wheat plants.

Due to differences in nutrient uptake, yield components of rice were also varied. Significantly higher shoot dry matter was produced due to sufficient uptake of N, P and K from TC2, TC4 and TG3 (Table 7). Plant height increased due to supplementation to PP with CM or CM plus RR. Although TG3 plants were little shorter than TC2 and TC4, they were able to produce significantly higher number of tillers than other treatments. Moreover, TG3 produced significantly higher number of panicles with TC4 but the former could not produce long panicles like the latter and TC2. Significantly higher numbers of spikelets per panicle were observed in TC2, TC4 and TG3 due to sufficient uptake of nutrients. Compost of only PP (TC1) supplied considerable amount of nutrients for wheat and rice, sometimes it supplied greater amounts of nutrients than other organic matter supplemented GM.

Pea based organic fertilizers supplied sufficient nutrients to wheat and rice but there is a question whether these fertilizers can contribute to minimize chemical fertilizer use or not. According to Fortuna et al. (2003), compost is even better than inorganic N fertilizer for N uptake by plant due to decreased $NO_3$ leaching. Our results suggest that pea based compost and GM could

**Table 7.** Effects of compost and green manure on yield contributing characters of rice.

| Treatments | DWS (g $hill^{-1}$) | Plant height (cm) | Tiller | Panicle | Length of panicle (cm) | No. of spikelet $panicle^{-1}$ |
|---|---|---|---|---|---|---|
| | | | (number $hill^{-1}$) | | | |
| TC1 | 16.42c | 100.0c | 8.75c | 8.25c | 16.90d | 59.33c |
| TC2 | 26.64a | 105.3a | 13.58a | 10.92b | 18.30ab | 72.59a |
| TC3 | 20.71b | 102.0b | 9.08bc | 8.20c | 17.83bc | 68.04b |
| TC4 | 27.11a | 106.0a | 13.85a | 12.60a | 18.60a | 74.56a |
| TG1 | 12.65d | 98.9cd | 7.75c | 6.70d | 16.25e | 56.05cd |
| TG2 | 20.26b | 97.3d | 9.75bc | 9.51bc | 15.62ef | 59.43c |
| TG3 | 28.72a | 103.4b | 13.50a | 12.70a | 16.20e | 71.80ab |
| TG4 | 22.69b | 99.2c | 10.91b | 9.50bc | 17.25cd | 68.33b |
| T0 | 9.66e | 93.0e | 4.58d | 4.60e | 15.20f | 54.39d |

DWS: Dry weight of shoot; Means followed by the same letter within a column are not statistically different according to Duncan's test at $P<0.05$.

be useful to supply P up to its second next crop of pea-wheat-rice cropping system. According to Regmi and Ladha (2002), organic fertilizer is an alternative to chemical fertilizer for P supply. Residual effect of compost is important for sustainability of nutrients, which was found to be even higher at the third cropping season than first season of rice (Tejada and Gonzalez, 2006).

The above results indicate that TC4 and TC2 composts were superior to others in almost all parameters for both crops. Moreover, compost showed higher values than its corresponding GM combinations. With time, TG3 also showed improvised performance for rice growth, meaning RR is a slow releasing fertilizer. The results exhibited the feasibility of adoption of pea in wheat-rice cropping system. After using pea residue on wheat-wheat cropping system positive N balance is found after two crops (Kumar and Goh, 2002). According to Kostov et al. (1995), compost has sharp impact over manure in respect of nutrient release. Thus, incorporation of pea, before wheat, in wheat-rice cropping system and use of compost with CM or CM plus RR would give greater benefit than wheat and rice cultivation with GM or other composts. Miller et al. (2006) monitor equal or greater positive cropping sequence effect of pea on subsequent wheat than mustard or wheat in cropping sequence, which supports our idea of incorporation of pea in wheat-rice cropping system. Rapeseed oil residue did not release nutrients quickly but it was not worthless as it contributed to good amount of residual nutrients.

## Conclusions and Recommendations

Composts of pea plant residue (PP) with dried chicken manure (CM) and CM plus rapeseed oil residue (RR) enriched soil with N, P, K and other nutrients, and increased nutrient uptake. Higher values were obtained for compost than for green manure (GM) of similar organic materials but GM with RR also supplied higher residual nutrients to rice which improved yield components. Despite having enough nutrients, RR did not contribute satisfactorily due to delay release but CM itself was efficient and stimulated RR to release nutrients. Pea compost with CM or CM plus RR is recommended for the improvement of soil for wheat and rice. Further research is required to find out the reason behind slow releasing character of RR. Field trials of the technology will be helpful before extensive use of the technology is adopted.

## ACKNOWLEDGEMENT

The authors gratefully acknowledge the contribution of International Harmony Club, Hashima, Gifu, Japan and Rotary Yoneyama Memorial Scholarship Foundation, Japan for financial support to the principal author.

### REFERENCES

Abdelhamid MT, Horiuchi T, Oba S (2004). Composting of rice straw with oilseed rape cake and poultry manure and its effects on faba bean (*Vicia faba L.*) growth and soil properties. Biores. Technol. 93: 183-189.

Abril A, Baleani D, Casado-Murillo N, Noe L (2007). Effect of wheat crop fertilization on nitrogen dynamics and balance in the Humid Pampas, Argentina. Agric. Ecosyst. Environ. 119: 171-176.

Arja HV, Maritta HS (1997). Evolution of microbiological and chemical parameters during manure and straw co-composting in drum composting system. Agric. Ecosyst. Environ. 66: 19-29.

Blake GR, Hartge KH (1986). Particle density. In: Klute A (ed). Methods of Soil Analysis. Part 1. Physical and Mineralogical Methods. American Society of Agronomy, Madison. pp. 377-382.

Bowden C, Spargo J, Evanylo G (2007). Mineralization and N fertilizer equivalent value of composts. Compost Sci. Util. 15(2): 111-118.

Bray RH, Kurtz LT (1945). Determination of total organic and available forms of phosphorus in soils. Soil Sci. 59: 39-45.

Eusuf Zai AK, Horiuchi T, Matsui T (2008). Effects of Green Manure and Compost of Pea Plant with Chicken Manure and Rapeseed Oil Residue on Growth, Yield and Efficiency of Nutrient Uptake by Wheat (*Triticum aestivum*). Compost Sci. Util. 16(4): xx-xx.

Fortuna A, Harwood RR, Robertson GP, Fisk JW, Paul EA (2003). Seasonal changes in nitrification potential associated with application of N fertilizer and compost in maize systems of southwest Michigan. Agric. Ecosyst. Environ. 97: 285-293.

Graham PH, Vance CP (2000). Nitrogen fixation in perspective: an overview of research and extension needs. Field Crops Res. 65: 93-106.

Gupta RK, Naresh RK, Hobbs PR, Jiaguo J, Ladha JK (2003). Sustainability of post-green revolution agriculture: the rice-wheat cropping systems of the Indo-Gangetic Plains and China. In: Ladha LK et al. (eds). Improving the Productivity and Sustainability of Rice-Wheat Systems: Issues and Impact. ASA Special Publication 65, ASA, Madison, WI, USA. 1:1-25.

Hirzel J, Walter I, Undurraga P, Cartagena M (2007). Residual effects of poultry litter on silage maize (Zea mays L.) growth and soil properties derived from volcanic ash. Soil Sci. Plant Nutr. 53: 480-488.

Jackson ML (1973). Soil Chemical Analysis. Prentice Hall of India Pvt. India.

Jeyabal A, Kuppuswamy G (2001). Recycling of organic wastes for the production of vermicompost and its response in rice-legume cropping system and soil fertility. Euro. J. Agron. 15: 153-170.

Kalra YP, Maynard DG (1994). Electrical conductivity and soluble salts. Methods manual for forest soil and plant analysis. Canadian Forest Service, Edmonton, Alberta, Canada. Information Report NOR-X-319, pp. 35-41.

Kostov O, Tzvetkov Y, Kaloianova N, Cleemput O (1995). Cucumber cultivation on some waste during their aerobic composting. Biores. Technol. 53: 237-242.

Kumar K, Goh KM (2002). Management practices of antecedent leguminous and non-leguminous crop residues in relation to winter wheat yields, nitrogen uptake, soil nitrogen mineralization and simple nitrogen balance. Euro. J. Agron. 16: 295-308.

Lefroy RBD, Chaitep W, Blair GJ (1994). Release of sulfur from rice residue under flooded and non-flooded soil conditions. Aust. J. Agric. Res. 45: 657-667.

Liang C, Das KC, McClendon RW (2003). The influence of temperature and moisture contents regimes on the aerobic microbial activity of a biosolids composting blend. Biores. Technol. 86: 131-137.

Lichthardt JJ, Jacobsen J (1991). Fertilizer Guidelines for Montana. Montana State University Extension Service. Montana. USA.

Miller MR, Engel RE, Holmes JA (2006). Cropping sequence effect of pea and pea management on spring wheat in the Northern Great Plains. Agron. J. 98: 1610-1619.

Nicholson FA, Chambers BJ, Smith KA (1996). Nutrient composition of poultry manures in England and Wales. Biores. Technol. 58: 279-284.

Oscarson P (2000). The strategy of the wheat plant in acclimating growth and grain production to nitrogen availability. J. Experi. Bot. 51: 1921-1929.

Patil SK, Singh U, Singh VP, Mishra VN, Das RO, Henao J (2001). Nitrogen dynamics and crop growth on an Alfisol and a Vertisol under a direct-seeded rainfed lowland rice-based system. Field Crops Res. 70: 185-199.

Pimentel D (1996). Green Revolution and chemical hazards. The Sci. Total Environ. 188 (Suppl. 1): S86-S98.

Ponnamperuma FN (1984). Straw as a source of nitrogen for wetland rice. In: Banta S, Mandoza CV (eds). Organic Matter and Rice. IRRI, Los Banos, Philippines. pp.117-136.

Raison RJ (1979). Modification of the soil environment by vegetation fires, with particular reference to nitrogen transformation: a review. Plant Soil 51: 73-108.

Regmi AP, Ladha JK (2002). Yield and Soil Fertility Trends in a 20-Year Rice-Rice-Wheat Experiment in Nepal. Soil Sci. Soc. Am. J. 66: 857-867.

Rochester IJ, Peoples MB, Hulugalle NR, Gault RR, Constable GA (2001). Using legumes to enhance nitrogen fertility and improve soil condition in cotton cropping systems. Field Crops Res. 70: 27-41.

Samar S, Malik RK, Mangat R, Singh S, Ram M (1999). Effect of rice straw burning on the efficacy of the herbicides in wheat (*Triticum aestivum*). Indian J. Agron. 44: 361-366.

Sharpe RR, Schomberg HH, Harper LA, Endale DM, Jenkins MB, Franzluebbers AJ (2004). Ammonia volatilization from surface-applied poultry litter under conservation tillage management practices. J. Environ. Qual. 33: 1183-1188.

Tejada M, Gonzalez JL (2006). Crushed cotton gin compost on soil biological properties and rice yield. Euro. J. Agron. 25: 22-29.

Tewari K, Sato T, Abiko M, Ohtake N, Sueyoshi K, Takahashi Y, Nagumo Y, Tutida T, Ohyama T (2007). Analysis of nitrogen nutrition of soybean plants with deep placement of coated urea and lime nitrogen. Soil Sci. Plant Nutr. 53: 772-781.

Thomas GW (1982). Exchangeable cations. 2nd edition. In: Page AL (ed). Methods of Soil Analysis. Part 2. Chemical and Microbiological Methods. American Society of Agronomy, Madison. pp. 159-165.

Mak KF, Chan NW, Lan A, Fang M, Zhou LX, Wu QT, Liao XD (2001). Co-composting of soybean residues and leaves in Hong Kong. Biores. Technol. 76: 99-106.

Zaidi A, Khan MS, Amil M (2003). Interactive effect of rhizotrophic microorganisms on yield and nutrient uptake of chickpea (*Cicer arietinum L.*). Euro. J. Agron. 19: 15-21.

Zaller JG, Moser D, Drapela T, Schmöger C, Frank T (2008). Effect of within-field and landscape factors on insect damage in winter oilseed rape. Agric. Ecos. Environ. 123: 233-238.

Zmora-Nahum S, Hadar Y, Chen Y (2007). Physico-chemical properties of commercial composts varying in their source materials and country of origin. Soil Biol. Biochem. 39: 1263-1276.