BIBLIOGRAPHY

BERNARD, RANDY M. OCTOBER 2009. Performance of Celery (*Apium graveolens var PS*) on Soil Amended with Organic Materials as Source of Nitrogen. Benguet State University, La Trinidad, Benguet.

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ABSTRACT

The experiment was conducted at the Department of Soil Science Experimental Area, College of Agriculture, Benguet State University, La Trinidad, Benguet from November 2008 to April 2009 to; to determine the performance of celery grown in soil amended with organic materials as source of nitrogen. Specifically, the study was conducted to: 1] determine the effects of different organic materials on the growth and yield of celery; 2] determine the influence of organic materials on some soil properties; 3] compare the soil pH, dry matter yield and amount of available N released at different growth stages of celery; and 4] identify the potential organic material as soil amendment and source of N for celery production.

Application of different organic materials improved the growth and yield and dry matter yield of celery.

Application of 20 tons/ha fresh wild sunflower in situ proved to be the best for celery production.

All organic materials generally enhanced the OM and available N content of the soil but at varied levels. The peak of the available N release was noted at 45 DAT.

Further, the soil pH was slightly decreased by the different organic materials except chicken manure which lowered the value.

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INTRODUCTION

Celery (Apium *graveolens Var PS*) is one of the crops that thrive best in the Cordillera, Philippines. This is distinctly a cool season crop which thrives best in areas with a monthly mean temperature ranging from 15-18^{0}C. It grows best on sandy or sandy loam soil with sufficient organic matter and soil pH requirement ranging from 6.0 to 6.8 (Knott and Deanon, 1987). It has a high marketable demand and price due to its uses like pre-dinner and appetizers, salad, flavoring, soap, juices, and dressing as well as an excellent vegetable, either stewed or creamed (Thompson and Kelly, 1959). It is a good source of vitamin A, ascorbic acid, calcium and food energy (Knot and Deanon, 1967). Besides food purposes, it is used in aromatherapy and other traditional way of healing. Eating celery reduces high blood pressure and gives the effect of calmness. Celery clears uric acid from painful joints and may also help the treatment of arthritis and rheumatic problems. It also helps the kidney by acting as anti-inflammatory and anti-oxidant (Hippocrates, 2006).

Celery has become one of the most profitable cash crops, however, its production entails a lot of expenses from the use of inorganic fertilizers apart from destroying the soil. Organic matter is the major source of nitrogen. Amending the soil with organic materials is one of the best alternative sources of N because it is cheaper, available and abundant in the locality. Instead of being thrown away as waste, they can be used as fertilizers for the crops. Organic matter was reported to improve the soil properties and have a long effect on the natural fertility of the soil.

The study was conducted to:

1. determine the effects of different organic materials on the growth and yield of celery;

2. determine the influence of organic materials on some soil properties;

3. compare the soil pH, dry matter yield and amount of available N released at different growth stages of celery; and

4. identify the potential organic material as soil amendment and source of N for celery production.

This study was conducted at the Soil Science Department experimental area, College of Agriculture, Benguet State University, La Trinidad Benguet from November 2008 to March 2009.

REVIEW OF LITERATURE

Organic Matter

Brady and Weil (2000) claimed that the organic matter binds mineral particles into granular soil structure, reducing plasticity, cohesion and stickiness of clayey soils which are largely responsible for the loose manageable condition of productive soils. It also increases the amount of water that the soil can hold. They also stated that the addition of organic mulch into the soil surface encourages earthworm activity, which in turn leads to the production of burrows and other biosphere which in turn increases the infiltration of water and decreases its loss as surface run off.

In 1987, Fellet as cited by Tuba-ang (2008) stated that when organic residues are in the process of becoming soil humus, they supply some of the essential nutrients needed by plants.

Aside from nutrient improvement of the soil properties, organic matter still gives many more advantageous effects especially in the plant growth of crops (Brady and Weil, 1996). Various growth promoting compounds like vitamins, amino acids, auxins and gibberellins are formed as organic matter decay.

Organic matter also increases the cation exchange capacity of the soil thereby reducing leaching losses of elements such as calcium and magnesium. The mineralization of the nutrient present in organic matter provides continuous supply of nitrogen, sulfur and phosphorus to the crop (Tisdale and Nelson, 1975). Similar effect on soils was corroborated by Brady and Weil (2000). In addition, the water holding capacity of the soil was also enhanced together with other constituents for microorganisms are provided.

Murakami (1991) stated that adding and returning of organic matter to the soil is essential. It is only organic matter that can provide the necessary elements for growing plants

Organic Fertilizer

Organic fertilizer supply some amount of the nutrient requirements of the crops and promote favorable soil properties, such as granulation, good tilth for efficient aeration, easy root penetration and improvement of water holding capacity (PCARRD, 1982)

Dao-ines, (1994) stated that organic fertilizers improve the soil structure and conserve soil moisture making it ideal for vegetable production because vegetable requires soil rich in organic matter.

In addition, Kinoshita (1972) stated that organic fertilizers or droppings contain mainly of nitrogen which tends to improve the physical properties of the soil.

In 1996, Brady and Weil as cited by Lazo (2006) stated that both fulvic and humic acid in the soil solution even in small quantities enhances certain aspects of plant growth. Components of these substances probably act as regulator of specific plant functions such as cell elongation and lateral root initiation.

Chicken Manure

Growth of plants applied with chicken dung is enhanced, resulting to higher marketable yield. This superiority of chicken dung may be attributed to more nutrient contents, readily available nutrients or combination of both (Eslay, 1996).

Jones, (1982) likewise found that manure contains essential plant nutrients especially nitrogen , phosphorus, and potassium as well as some trace elements not generally found in chemical fertilizer.

A study of Sumedca (1988) revealed that application of 1 ton/ha chicken manure enhances growth and yield of cabbage. Application of 4 tns /ha of chicken manure, however was suggested by HARC (1986) for a strawberry field under La Trinidad condition.

In 1986, Pandosen reported that potato tubers responded more to chicken manure application. The weight of marketable tubers applied with chicken manure was higher than the weight of marketable tubers applied with compost. Plants with no organic manure recorded the lowest weight of marketable tubers. Moreover Labutan (1996), revealed that plants applied with chicken manure had heavier yield than those applied with mushroom compost.

<u>Wild Sunflower</u>

Wild sunflower which is abundant in the highlands can be a perfect substitute organic nitrogen source and as starter of compost for it hastens further decomposition. Sunflower also increases the nutrient content of compost (Victor, 1974). Through laboratory analysis, Pandosen (1986) found that fresh wild sunflower contains 3.76% nitrogen and wild sunflower based compost contains 3.22% nitrogen. It is therefore a good source of organic nitrogen.

Yango (1998) found that incorporation of chopped fresh wild sunflower is effective in improving the growth and yield of Bontoc rice when applied 1 week before planting time. In the case of garden pea, Durante (1983) claimed that application of 8 tons of fresh wild sunflower per hectare gave highest yield.

Vermicompost

Vermicomposting is the final phase of the compost processes where compost is turned into dirt and is dominated by soil microorganisms as opposed to ordinary compost. Ordinary compost needs to be digested well before it can give it's full benefits, while worm casting (Vermicompost) are as ready for plant use (Acme Warm Farm, 2002) as cited by Lagman (2003).

In addition, Williams et al. (1993) reported that Vermicompost help incorporate organic matter, improve soil structure and enhance water movement through the soil which improve plant root growth.

Vermicompost has a pH of 7-7.5 and a C: N ratio of 12-15:1. Through chemical analysis it contains 1.75- 2.5 %N, about 1.25-2 %K, calcium, magnesium, sulphate which are 3- 5% times better than farm manure. Iron, zinc, manganese and copper are 200 to 700 ppm while cobalt, molybdenum and boron are also in the soluble form in sufficient quantities (Singh, 2001).

Further, vermicompost has a nutrient and organic matter level much higher than that of the surrounding soil. Each day, they produce nitrogen, phosphorus, potassium and many micronutrients in a form that all plants can use (IES, 1984).

Smith (1984) studied that worms make other contribution such as adding calcium carbonate. A compound which help moderate the pH. Certain earthworms can help change acid to alkaline soils toward a more neutral pH.

<u>Compost</u>

Application of compost enriches the soil organic matter, and improves the physical, chemical and biological properties of the soil. Compost application builds up the water absorbing capacity of the soil. Soils with compost have less water evaporation than the soil without compost (Dagoon and Sangatanan, 1985). They added that application of compost activates soil microorganisms consequently increasing the availability of nutrients that plant feed on.

Tan (1975) as cited by Imong (2003) revealed that composts are used to improve the soil conditions in various ways. It granulates the soil particles and makes it loose for easy tillage and improves soil drainage aside from being a good source of plant nutrients.

Pel-o (2004) stated that composts increase the organic matter content of soil. Addition of organic matter usually increases pH of acid soils.

Kinoshita (1972) as cited by Andaya (1996) reported that organic fertilizers such as composts and manures are very important needs in vegetable production. They maintain not only soil fertility but also continuous production of vegetables.

MATERIALS AND METHODS

Organic materials such as Vermicompost, dry chicken manure, BSU compost, fresh wild sunflower and fresh cabbage refuse, were gathered and chopped in the field. Chemical reagents, glasswares and laboratory equipments, were used in the chemical analysis.

Eight weeks old celery seedlings were first established in the nursery prior to transplanting. Planting of seedlings were done per plot following a distance of 30x30 cm double row with a total of 66 hills in a 10 m^2 plot.

Organic materials, fresh wild sunflower, fresh cabbage refuse, and dry chicken manure were placed and incorporated thoroughly at the center furrow of each plot. These were covered with soil and left for 7 days before transplanting (DAT) following the different treatments. Application of inorganic fertilizer at the rate of 120-120-120 kg/ha N-P_2O_5-K_2O. All the P and K and ½ of N were applied basally and the other half of N was side dressed at hilling up. Other cultural management in growing celery like weeding, irrigation, and other management practices were employed.

Destructive sampling was employed ay 15, 30, 45, 60 and 70 days after transplant (DAT) for plant analysis. Random soil sampling was done by inserting a soil auger to a depth of 20 cm, taking at least 5 borings on the designated area at the end each plot. The soil and plant samples were taken simultaneously during the different growth stages of celery, which are at 15, 30, 45, 60, and 70 DAT (harvest time).

The experiment was laid out in a Randomized Complete Block Design (RCBD) replicated three times with the following treatments:

Treatments:

T_{1-} Control

T_2-120-120-120-N-$P_2O_{5-}K_2O$ kg/ha

T_3- 5 tons/ ha chicken manure

T_4- 20 tons/ha Vermicompost

T_5- 20 tons/ha BSU Compost

T_6- 20 tons/ha Fresh Wild Sunflower

T_7- 20 tons/ha Fresh Cabbage Refuse

The data gathered were:

A. Growth and Yield Parameters

1. Final height per plant (cm). Ten samples plants were randomly tagged from different treatments for the determination of plants height.

2. Fresh weight per plant (kg). The fresh weight per plant was determined from the same ten sample plants obt6ained in the determination of the final height sample plants

3. Dry matter yield (DMY) per plant (gm). The plants were gathered 1 each per treatment per growth stages and weighed for the determination of DMY. Plants were chopped and sun dried, oven dried, weighed and average taken. The dry matter yield of celery was obtained by drying the plant sample in a draft oven at a temperature of 70^0 Celsius, cooled in desiccator and weighed. The formula used was DMY = FW/ (1+%MC/100).

4. Total yield (kg/ha). The yield per plot was recorded and converted to tons per hectare.

B. Chemical Properties of the Soil

1. Soil pH. The pH of the soil was determined using the 1:2 $CaCl_2$ solution by electrometric method.

2. Organic matter content of the soil (%). The organic matter content of the soil was analyzed using the Walkley and Black Method.

3. Available nitrogen (N) content of the soil (mg/kg). Ammonium nitrogen and nitrate – nitrogen content of the soil at every growth stage were determined using the Steam Distillation Method.

C. Statistical Analysis

Data analysis was done using the Analysis of Variance (ANOVA) and the Duncan's Multiple Range Test (DMRT) to test the level of significance between means.

RESULTS AND DISCUSSION

Final Height Per Plant

Table 1 shows that celery plants grown under the control registered the lowest mean of 47.00 cm. Promising effects of different organic materials were observed on the height of the plants. It is observed that the individual effects of fresh wild sunflower and chicken manure were found to be comparable to the recommended rate with means of 55.96 cm and 55.40 cm respectively. The result implies that fresh wild sunflower applied in situ at a rate of 20 tons/ha can enhance celery growth similar to the recommended inorganic fertilizer. Chicken manure applied in situ at a rate of 5 tons/ha was next. These were followed in the order by BSU compost, Vermicompost and fresh cabbage refuse.

Table 1. Final height per plant as affected by different organic materials

TREATMENT	MEAN (cm)
Control	47.00[c]
120-120-120 kg/ha N-P_2O_5-K_2O	55.97[a]
Dry chicken manure 5 tons/ha	55.40[a]
Vermicompost 20 tons/ha	50.37[b]
BSU compost 20 tons/ha	51.39[b]
Fresh wild sunflower 20 tons/ha	55.96[a]
Fresh cabbage refuse 20 tons/ha	49.04[bc]

Means with the same letter/s are not significantly different at 5% level by DMRT

Organic materials therefore, are good sources of nutrients and organic matter for plants. In agreement Brady and Weil (2000) reported that organic matter is a source of plant nutrients phosphorus, sulfur and a primary source of nitrogen for most plants. Dao-ines, (1994) stated that organic fertilizer improve the soil structure and conserve soil moisture making it ideal for vegetable production because vegetables requires soil rich in organic matter.

Fresh Weight Per Plant

Among the organic materials applied, fresh wild sunflower (20 tons/ ha) registered the highest fresh weight with a mean of 1.257 kg (Table 2). Plots treated with chicken manure at a rate of 5 tons/ha followed with a mean of 1.203 kg. Vermicompost, BSU compost and fresh cabbage refuse came next respectively. Lightest plants were registered by the control. A study conducted by Durante (1983) showed that application of 8 tons/ha of fresh wild sunflower registered heavier garden pea pods.

The weight per plant obtained from the above organic materials however, are in comparable with that of the result obtained from the use of the recommended rate of inorganic fertilizer. The result could be attributed to the higher amount of NPK from the inorganic fertilizer. Nutrients derived from organic materials vary from material to material. Further, these come in smaller amounts and the release is slow. Organic materials which are residues of dead and dying plants materials are reservoirs of nitrogen, phosphorus, sulfur, and other macronutrient elements essential for plant growth (Jones, 1982).

Table 2. Fresh weight per plant as affected by different organic materials

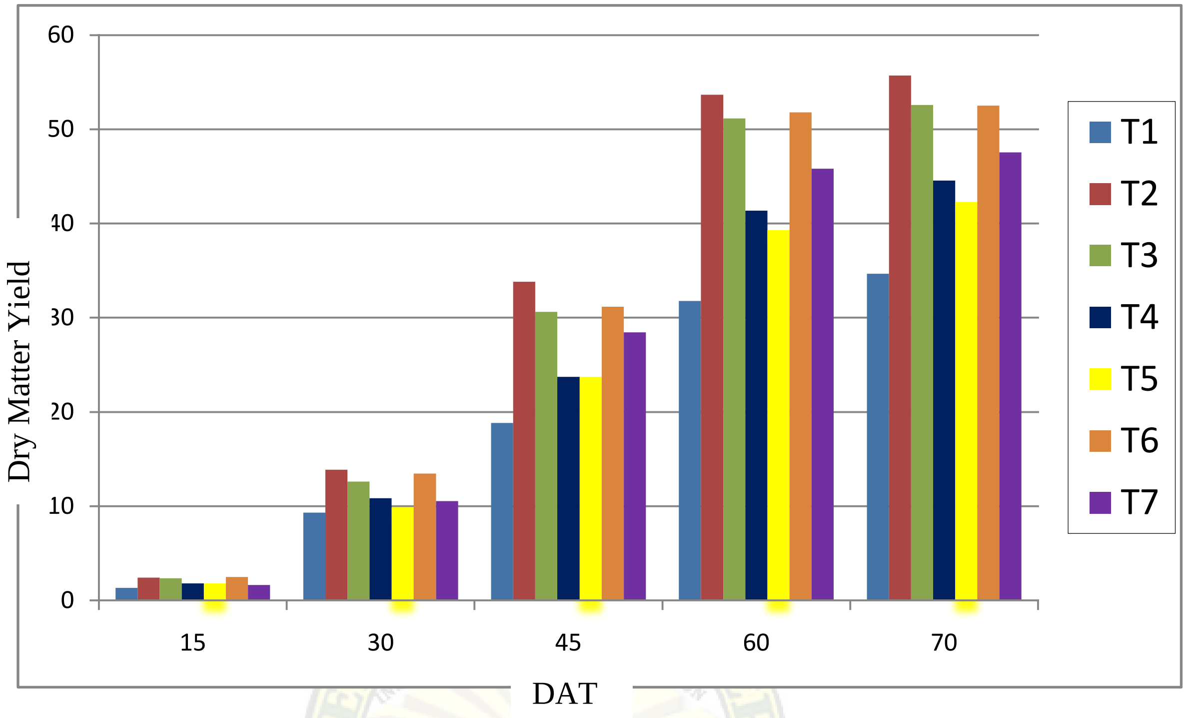
TREATMENT	MEAN (kg)
Control	0.92[d]
120-120-120 kg/ha N-P_2O_5-K_2O	1.31[a]
Dry chicken manure 5 tons/ha	1.20[b]
Vermicompost 20 tons/ha	1.09[c]
BSU compost 20 tons/ha	1.06[c]
Fresh wild sunflower 20 tons/ha	1.26[ab]
Fresh cabbage refuse 20 tons/ha	1.06[c]

Means with the same letter/s are not significantly different at 5% level by DMRT

Dry Matter Yield Per Plants at Different Growth Stages

Dry matter yield at different growth stages is shown in Figure 1. The use of fresh wild sunflower at a rate of 20 tons/ha outranked the other organic materials in dry matter yield of celery at 15 DAT to harvest (68 DAT). Application of chicken manure at a rate of 5 tons/ha ranked second and respectively followed by fresh cabbage refuse, vermicompost, BSU compost each having a rate of 20 tons/ha. The lowest DMY was obtained from the control. It is evident that application of the different organic materials does not match that of the inorganic fertilizer, however, application of the organic materials either as fresh or dry is better than the use of composted materials.

Figure 1. Dry matter yield (DMY) per plant at different growth stages as affected by different organic materials



Dry Matter Yield Per Plant 15 DAT

The dry matter yield per plant at 15 DAT is shown in Table 3. Plants treated with fresh wild sunflower (20 tons/ha) registered the highest DMY of 2.47 grams which proved to be comparable to the recommended rate of inorganic fertilizer of 2.40 grams. The result implies the fast decomposition and release of nitrogen from wild sunflower when freshly applied in situ. Pandosen (1986) stated that chopped fresh wild sunflower alone, are fully decomposed in two weeks (14 days) thus faster release of essential nutrients. In addition Yango (1998) found that incorporation of chopped fresh wild sunflower is effective in improving the growth and yield of Bontoc rice when applied 1 week before planting time.

The lowest mean were observed in control.

Table 3. Dry matter yield per plant 15 DAT as affected by different organic materials

TREATMENT	MEAN (g)
Control	1.33[d]
120-120-120 kg/ha N-P_2O_5-K_2O	2.40[ab]
Dry chicken manure 5 tons/ha	2.33[ab]
Vermicompost 20 tons/ha	1.80[bc]
BSU compost 20 tons/ha	1.83[bc]
Fresh wild sunflower 20 tons/ha	2.47[a]
Fresh cabbage refuse 20 tons/ha	1.63[cd]

Means with the same letter/s are not significantly different at 5% level by DMRT

Dry Matter Yield Per Plant 30 DAT

Dry matter yield of celery at 30 DAT amended with different organic materials as a source of N is shown in Table 4. The highest DMY was obtained from plants grown in plots treated with fresh wild sunflower with a mean of 13.467 grams. This result may be due to the fast decomposition and high N content of the organic material, thus fast release of nutrients to be utilized by the plants. Pandosen (1986) found that fresh application of wild sunflower in situ proved to be better than sunflower-based compost in effecting growth and yield of snap bean. Second to fresh wild sunflower is chicken manure followed by Vermicompost, cabbage refuse and BSU compost.

The lowest dry matter yield was registered by the control.

Table 4. Dry matter yield per plant 30 DAT as affected by different organic materials

TREATMENT	MEAN (g)
Control	9.30[d]
120-120-120 kg/ha N-P_2O_5-K_2O	13.87[a]
Dry chicken manure 5 tons/ha	12.60[b]
Vermicompost 20 tons/ha	10.83[c]
BSU compost 20 tons/ha	9.90c[d]
Fresh wild sunflower 20 tons/ha	13.47[ab]
Fresh cabbage refuse 20 tons/ha	10.53[c]

Means with the same letter/s are not significantly different at 5% level by DMRT

Dry Matter Yield Per Plant 45 DAT

As the plants grow, they accumulate dry matter. It is shown in Table 5 that amending the soil with organic materials like fresh wild sunflower, chicken manure fresh cabbage refuse, vermicompost and BSU compost greatly increased the DMY 45 DAT in their respective order. On the other hand, the control registered the lowest DMY 45 DAT. It is also inferred in the result that dry or fresh organic materials, when applied in situ, will result to a higher accumulated DMY than composted materials. This could be attributed to the direct absorption of the released nutrients by the soil micelle in situ where they are reserved for plant uptake, while composted materials may loose nutrients during the decomposition process in the compost site. Santil (2009) stated that amending the soil with either dry or fresh organic material to the field in situ gave better curd yield of broccoli than the composted ones.

Table 5. Dry matter yield per plant 45 DAT as affected by different organic materials

TREATMENT	MEAN (g)
Control	18.83[e]
120-120-120 kg/ha N-P_2O_5-K_2O	33.83[a]
Dry chicken manure 5 tons/ha	30.63[bc]
Vermicompost 20 tons/ha	23.73[d]
BSU compost 20 tons/ha	23.73[d]
Fresh wild sunflower 20 tons/ha	31.17[b]
Fresh cabbage refuse 20 tons/ha	28.47[c]

Means with the same letter/s are not significantly different at 5% level by DMRT

Dry Matter Yield Per Plant 60 DAT

Table 6 shows the dry matter yield of celery 60 DAT as affected by the different organic materials as soil amendment and source of N. Application of fresh wild sunflower with a mean of 51.8 g registered the highest. The use of chicken manure cabbage refuse, vermicompost, BSU compost and control followed with means of 51.17, 45.83, 41.37, 39.30 and 31.77 grams respectively. The result may be due to the varied decomposition rate and N contents of the organic materials. Cox and Jackson (1960) found out that manure hasten decomposition process in soil because it contains many organisms. American Corporation (1973) stated that organic manure when applied to the soil release high amounts of nitrogen.

Table 6. Dry matter yield per plant 60 DAT as affected by different organic materials

TREATMENT	MEAN (g)
Control	31.77[d]
120-120-120 kg/ha N-P_2O_5-K_2O	53.67[a]
Dry chicken manure 5 tons/ha	51.17[a]
Vermicompost 20 tons/ha	41.37[c]
BSU compost 20 tons/ha	39.30[c]
Fresh wild sunflower 20 tons/ha	51.80[a]
Fresh cabbage refuse 20 tons/ha	45.83[b]

Means with the same letter/s are not significantly different at 5% level by DMRT

Final Dry Matter Yield Per Plant

The dry matter yield of celery at harvest time is presented in Table 7. It is observed that the effect of chicken manure and fresh wild sunflower are at par with the recommended rate of inorganic fertilizer. The result implies that the fresh wild sunflower and chicken manure, when added separately can provide the nutrient needs of celery. This could be attributed to the varied nutrient contents of fresh wild sunflower and chicken manure contents as previously mentioned. Jones (1982) found that manure contains essential plants nutrients especially nitrogen, phosphorus, and potassium as well as some trace elements not generally found in chemical fertilizers.

Table 7. Final dry matter yield per plant as affected by different organic materials

TREATMENT	MEAN (g)
Control	34.67[d]
120-120-120 kg/ha N-P_2O_5-K_2O	55.73[a]
Dry chicken manure 5 tons/ha	52.60[a]
Vermicompost 20 tons/ha	44.57[bc]
BSU compost 20 tons/ha	42.27[c]
Fresh wild sunflower 20 tons/ha	52.53[a]
Fresh cabbage refuse 20 tons/ha	47.57[b]

Means with the same letter/s are not significantly different at 5% level by DMRT

Total Yield of Celery

Table 8 shows the total yield of celery as affected by the different organic materials. Application of fresh wild sunflower at a rate of 20 tons/ha produced the highest mean total yield of 82.96 tons/ha. Plots treated with chicken manure at a rate of 5 tons/ha came second with a mean of 79.40tons/ha and respectively followed by vermicompost, BSU compost and fresh cabbage refuse, each having a rate of 20 tons per hectare and the lowest mean were observed in the control. Result show that there's a need to amend the soil with organic materials as source of nutrient elements particularly N and enhance the soil characteristics.

Table 8. Total yield of celery as affected by different organic materials

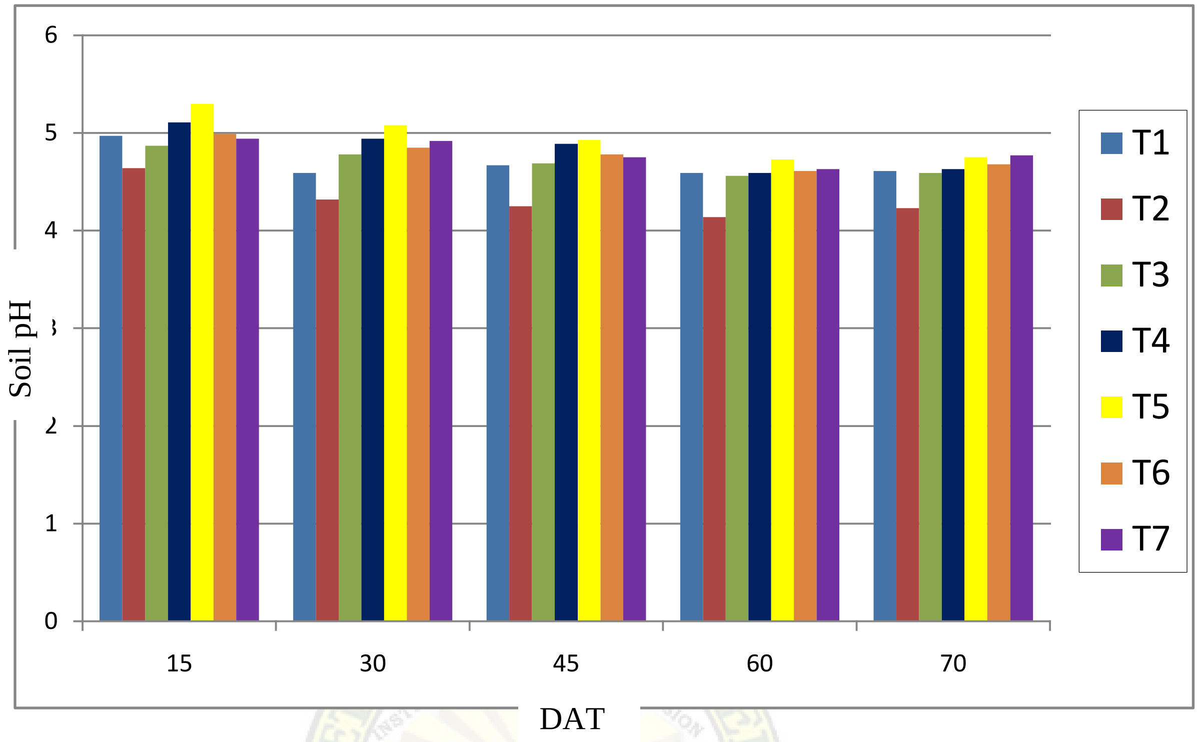
TREATMENT	MEAN (tons/ha)
Control	60.52[d]
120-120-120 kg/ha N-P_2O_5-K_2O	86.66[a]
Dry chicken manure 5 tons/ha	79.40[b]
Vermicompost 20 tons/ha	71.94[c]
BSU compost 20 tons/ha	69.75[c]
Fresh wild sunflower 20 tons/ha	82.96[ab]
Fresh cabbage refuse 20 tons/ha	69.70[c]

Means with the same letter/s are not significantly different at 5% level by DMRT

Soil pH at Different Growth Stages

Figure 2 presents the soil pH as affected by the different organic materials at different growth stages of celery. Amended plots with organic materials including the control generally decreased soil pH 15 DAT to harvest (68 DAT). As observed from early stage of the crop there was a decrease of soil pH from 15 to 45 DAT except for the vermicompost and BSU compost with a slight decrease in value. On the other hand, inorganic fertilizer (120-120-120 N-P_2O_5-K_2O kg/ha) registered the lowest value of soil pH of 4.23.

Figure 2. Soil pH at different growth stages as affected by different organic materials



<u>Soil pH 15 DAT</u>

Table 9 shows the pH of the soil 15 DAT as affected by different organic materials as soil amendment and source of N. Plots treated with BSU compost (20 tons/ha) registered the highest soil pH of 5.30. Those plots treated with Vermicompost (20 tons/ha) followed with a mean of 5.11. It appears that application of composted materials increase the soil pH at an early growth stage while those applied either as dry or fresh tend to decrease soil pH. This could be attributed to the release of organic acids during the decomposition process. The lowest pH was obtained from plots treated with chicken manure. This indicates the acidifying effect of chicken manure which close to the effect of inorganic fertilizer.

Table 9. Soil pH 15 DAT as affected by different organic materials

TREATMENT	MEAN
Control	4.97^{bc}
120-120-120 kg/ha N-P_2O_5-K_2O	4.64^{c}
Dry chicken manure 5 tons/ha	4.87^{bc}
Vermicompost 20 tons/ha	5.11^{ab}
BSU compost 20 tons/ha	5.30^{a}
Fresh wild sunflower 20 tons/ha	4.99^{ab}
Fresh cabbage refuse 20 tons/ha	4.94^{bc}
Initial	4.88

Means with the same letter/s are not significantly different at 5% level by DMRT

According to Davies et al. (1993) decomposed organic matter holds more exchangeable and available nutrient cations such as Ca, Mg, and ammonium. The result may be attributed to the readily available organic matter in retaining nutrients from fertilizers applied but also in increasing the buffering capacity of the soil pH. Additions of organic matter usually increase the pH of acid soils.

Soil pH 30 DAT

All of the soil pH 30 DAT as affected by the different organic materials decreased, however, the highest soil pH was registered by those treated with composted materials (Vermicompost and BSU compost), followed by those treated with fresh or dry materials in situ. The lowest soil pH was observed in the control plots followed by those

Table 10. Soil pH 30 DAT as affected by different organic materials

TREATMENT	MEAN
Control	4.59[c]
120-120-120 kg/ha N-P_2O_5-K_2O	4.32[d]
Dry chicken manure 5 tons/ha	4.78[c]
Vermicompost 20 tons/ha	4.94[ab]
BSU compost 20 tons/ha	5.08[a]
Fresh wild sunflower 20 tons/ha	4.85[b]
Fresh cabbage refuse 20 tons/ha	4.92[ab]
Initial	4.88

Means with the same letter/s are not significantly different at 5% level by DMRT

treated with chicken manure as compared to the use of other organic materials. However, acidification of the soil is greater still when inorganic fertilizers are used (Table 10). Nelson and Tisdale (1975) stated that the additions of salts, such as those contained in fertilizers, to sesquioxide-coated, interlayered minerals increase the hydrolysis of non exchangeable Fe and Al resulting in an increase in the H^+ ion concentration of the soil solution, and hence a lower pH. The result conforms to the study of Fullen and Catt (2004) that addition of organic matter increases in the soil pH of acid soils.

Soil pH 45 DAT

Table 11 shows the result of soil pH at 45 DAT as affected by the different organic materials as soil amendment and as source of N. Obviously, plots treated with

Table 11. Soil pH 45 DAT as affected by different organic materials

TREATMENT	MEAN
Control	4.67[b]
120-120-120 kg/ha N-P_2O_5-K_2O	4.25[c]
Dry chicken manure 5 tons/ha	4.69[b]
Vermicompost 20 tons/ha	4.89[a]
BSU compost 20 tons/ha	4.93[a]
Fresh wild sunflower 20 tons/ha	4.78[ab]
Fresh cabbage refuse 20 tons/ha	4.75[ab]
Initial	4.88

Means with the same letter/s are not significantly different at 5% level by DMRT

inorganic gave the lowest pH followed by the control (4.67) as compared to plots treated with organic materials. The ammonium released from inorganic fertilizer undergoes nitrification releasing H^+ ion which lowers the soil pH (Tisdale and Nelson, 1975). It is further observed from plots treated with organic materials that chicken manure application registered the lowest pH compared to the others. This result could be attributed to the fast decomposition rate and release of acids upon decomposition.

<u>Soil pH 60 DAT</u>

The pH of the soil 60 DAT as affected by different organic materials as amendment and as a source of N is shown in Table 12. It is observed that the soil pH at 60 DAT further decreased but the slight changes are not significantly different among the

Table 12. Soil pH 60 DAT as affected by different organic materials

TREATMENT	MEAN
Control	4.59[a]
120-120-120 kg/ha N-P_2O_5-K_2O	4.14[b]
Dry chicken manure 5 tons/ha	4.56[a]
Vermicompost 20 tons/ha	4.59[a]
BSU compost 20 tons/ha	4.73[a]
Fresh wild sunflower 20 tons/ha	4.61[a]
Fresh cabbage refuse 20 tons/ha	4.63[a]
Initial	4.88

Means with the same letter/s are not significantly different at 5% level by DMRT

organic materials. However, plots treated with chicken manure registered the lowest pH which is comparable to the plots that received inorganic fertilizers. Results imply that organic materials, upon decomposition release acids but minimal compared to those released from inorganic fertilizers

Final Soil pH

Table 13 presents a slight increase in the final soil pH as affected by different organic materials but the effect is negligible. It remains, however, that those treated with chicken manure registered the lowest soil pH of 4.59 compared to the other organic materials. The result implies a disadvantageous effect of chicken manure on the soil pH even up to this growth stage (70 DAT).

Table 13. Final soil pH as affected by different organic materials

TREATMENT	MEAN
Control	4.61[a]
120-120-120 kg/ha N-P_2O_5-K_2O	4.23[b]
Dry chicken manure 5 tons/ha	4.59[a]
Vermicompost 20 tons/ha	4.63[a]
BSU compost 20 tons/ha	4.75[a]
Fresh wild sunflower 20 tons/ha	4.68[a]
Fresh cabbage refuse 20 tons/ha	4.77[a]
Initial	4.88

Means with the same letter/s are not significantly different at 5% level by DMRT

Final Organic Matter Content of the Soil

All of the organic materials applied in situ has soil amendment greatly increased the organic matter content of the soil (Table 14). The lowest organic matter was obtained from the control. Application of vermicompost registered the highest organic matter content with a mean of 1.766%. Those treated with fresh cabbage refuse and dry chicken manure followed with means of 1.673% and 1.646% respectively. According to IES, (1984) it stated that vermicompost has a nutrient and organic matter level, much higher than that of the surrounding soil. Each day, they produce nitrogen, phosphorus, potassium and many micronutrients in a form that all plants can use.

Table 14. Final organic matter content of the soil

TREATMENT	MEAN (%)
Control	0.88[d]
120-120-120 kg/ha $N\text{-}P_2O_5\text{-}K_2O$	1.45[c]
Dry chicken manure 5 tons/ha	1.65[b]
Vermicompost 20 tons/ha	1.77[a]
BSU compost 20 tons/ha	1.50[c]
Fresh wild sunflower 20 tons/ha	1.51[c]
Fresh cabbage refuse 20 tons/ha	1.67[b]
Initial	0.81

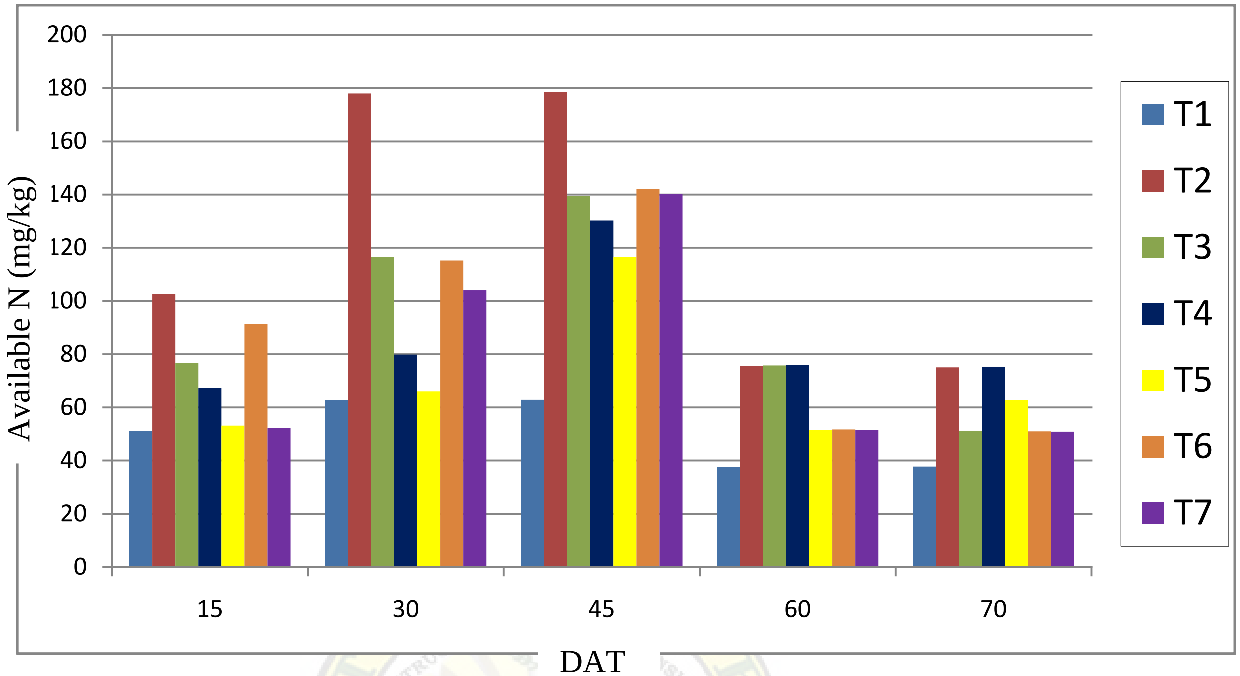
Means with the same letter/s are not significantly different at 5% level by DMRT

<u>Available Nitrogen at Different Growth Stages</u>

The available nitrogen as affected by the different organic materials at different growth stages is shown in Figure 3. The use of organic materials generally increased the available N content of the soil from an initial of 46.16 mg/kg. Application of fresh wild sunflower gave the highest available N at 15 DAT, however at 30 DAT, a gradual increase of available nitrogen from chicken manure in a dry state was observed.

The peak of the availability of nitrogen from organic materials is clear cut at 45 DAT. A sudden decrease of available nitrogen was observed at 60 DAT then stabilized at 68 DAT (harvest). Tuba-ang (2008) found that 13 weeks (90 days) incubation gave the highest available nitrogen release, however, this is without a standing crop. Results reveal, therefore, the influence of a crop on soil characteristics.

Figure 3. Available N at different growth stages as affected by different organic materials



Available Nitrogen 15 DAT

The available N content of the soil 15 DAT is shown in Table 15. Among the organic materials used, fresh wild sunflower applied at a rate of 20 tons/ha registered the highest mean of 91.46 mg/kg followed by chicken manure with a mean of 76.64 mg/kg. This result could be due to the high N content of wild sunflower (3.76%) and its fast decomposition rate. Through chemical analysis, Pandosen (1986) found that wild sunflower has 3.76% N, 0.0077% P, 4.44% K, 1.90 % Ca and .39% Mg. Further, full decomposition of wild sunflower is 2 weeks (14 days).

Application of inorganic fertilizer on the other hand, registered the highest mean of 102.71 mg/kg. This is due to the fact that inorganic fertilizer releases nutrients faster than organic materials. The result is supported by the statement of Bautista et al. (1983)

Table 15. Available N 15 DAT as affected by different organic materials

TREATMENT	MEAN (mg/kg)
Control	51.15[b]
120-120-120 kg/ha N-P_2O_5-K_2O	102.71[a]
Dry chicken manure 5 tons/ha	76.64[ab]
Vermicompost 20 tons/ha	67.20[ab]
BSU compost 20 tons/ha	53.18[b]
Fresh wild sunflower 20 tons/ha	91.46[ab]
Fresh cabbage refuse 20 tons/ha	52.29[b]
Initial	46.16

Means with the same letter/s are not significantly different at 5% level by DMRT

that inorganic fertilizers release great quantities of nutrients which can be easily absorbed by the roots of the plants.

Available Nitrogen 30 DAT

The available nitrogen content of the soil 30 DAT as influenced by different organic materials as soil amendment and source of N is shown in Table 16. Chicken manure (5 tons/ha) was found to have released the highest available N (116.53 mg/kg) among organic materials applied. This is followed by fresh wild sunflower (115.25 mg/kg) with a slight difference of 1.28 mg/kg. This result could be due to the high N content of chicken manure. Pure chicken manure contains 5% of nitrogen. According to Brady (1990) he stated that animal manure is a good source of nitrogen and it's the best

Table 16. Available N 30 DAT as affected by different organic materials

TREATMENT	MEAN (mg/kg)
Control	62.72[c]
120-120-120 kg/ha N-P_2O_5-K_2O	178.01[a]
Dry chicken manure 5 tons/ha	116.53[b]
Vermicompost 20 tons/ha	79.84[bc]
BSU compost 20 tons/ha	65.99[bc]
Fresh wild sunflower 20 tons/ha	115.25[bc]
Fresh cabbage refuse 20 tons/ha	103.99[bc]
Initial	46.16

Means with the same letter/s are not significantly different at 5% level by DMRT

material for maintaining the nitrogen content of the soil. In addition the superiority of chicken manure may be attributed to its readily available nutrients.

Available Nitrogen 45 DAT

After 45 DAT, The available N of the soil was greatly increased by the different organic materials amended to the soil (Table 17). Obviously, the control registered the lowest available N of 62.87 mg/kg because it only depended on N content of the soil. Further observation shows that plots treated with fresh wild sunflower registered the highest followed by fresh cabbage refuse and chicken manure. The result shows that application of the organic materials in situ either fresh or dry release more N than those composted materials. In addition, the peak of N release was notable at this growth stage.

Table 17. Available N 45 DAT as affected by different organic materials

TREATMENT	MEAN (mg/kg)
Control	62.87[c]
120-120-120 kg/ha N-P_2O_5-K_2O	178.52[a]
Dry chicken manure 5 tons/ha	139.50[ab]
Vermicompost 20 tons/ha	130.21[b]
BSU compost 20 tons/ha	116.53[b]
Fresh wild sunflower 20 tons/ha	142.02[ab]
Fresh cabbage refuse 20 tons/ha	140.05[ab]
Initial	46.16

Means with the same letter/s are not significantly different at 5% level by DMRT

This could be attributed to the succulence of freshly applied organic materials, fast decomposition rate and high N content of the organic material and low C:N ratio.

Available Nitrogen 60 DAT

Table 18 shows the available nitrogen content of the soil as affected by the different organic materials as a source of N. A notable decline on the available N content of the soil 60 DAT was observed. The result indicates that the N contained in the organic materials used were released and utilized between 45 to 60 DAT. Results imply that after 45 DAT, nutrient elements start to be depleted.

Table 18. Available N 60 DAT as affected by different organic materials

TREATMENT	MEAN (mg/kg)
Control	37.63[a]
120-120-120 kg/ha N-P_2O_5-K_2O	75.67[a]
Dry chicken manure 5 tons/ha	75.81[a]
Vermicompost 20 tons/ha	75.95[a]
BSU compost 20 tons/ha	51.42[a]
Fresh wild sunflower 20 tons/ha	51.70[a]
Fresh cabbage refuse 20 tons/ha	51.42[a]
Initial	46.16

Means with the same letter/s are not significantly different at 5% level by DMRT

Final Available Nitrogen

The final available N in the soil is presented in Table 19. A decline in the available N in the soil was observed as the plants grew older. It is inferred that plants utilized whatever N is present in the soil. Further observation revealed that plots treated with vermicompost (20 tons/ha) registered the highest available N with a mean of 75.33 mg/kg, indicating a slow decomposition rate. The effect of vermicompost is more on physical properties rather than on the available N released. According to Williams et al. (1993), vermicompost helps incorporate organic matter, improve the soil structure, and increase, and increase water movement through the soil and enhance plant root growth.

Table 19. Final available N content of the soil

TREATMENT	MEAN (mg/kg)
Control	37.77[b]
120-120-120 kg/ha N-P_2O_5-K_2O	74.99[a]
Dry chicken manure 5 tons/ha	51.28[ab]
Vermicompost 20 tons/ha	75.33[a]
BSU compost 20 tons/ha	62.72[ab]
Fresh wild sunflower 20 tons/ha	51.00[ab]
Fresh cabbage refuse 20 tons/ha	50.86[ab]
Initial	46.16

Means with the same letter/s are not significantly different at 5% level by DMRT

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The experiment was conducted at the Department of Soil Science Experimental Area, College of Agriculture, Benguet State University, La Trinidad, Benguet from November 2008 to April 2009 to; 1) determine the effect of organic materials on the growth and yield of celery; 2) determine the influence of organic materials on some soil properties; 3) compare the soil pH, dry matter yield and amount of available N released at different growth stages of celery; and 4) identify the potential organic material good for celery production.

Results show that application of fresh wild sunflower in situ effected the growth and yield in terms of final height, fresh weight per plant and DMY at different growth stages and total yield of celery plants. The favorable influence of different organic materials on the growth and yield performance are in the order: chicken manure, vermicompost, BSU compost, and cabbage refuse.

On the other hand, the soil pH was decreased by the application of different organic materials at an early growth stage (15 DAT). However, as the materials decomposed, the pH at 45 days after transplanting were slightly increased from soils applied with BSU compost and vermicompost over the initial pH value. Further observation showed that application of chicken manure decreased the soil pH to a greater extent that it almost leveled with the acidifying effect of inorganic fertilizer. OM content of the soil, on the other hand, was enhanced by all the organic materials used, however, the use of vermicompost gave the highest final OM at harvest.

A general increase in the available N in the soil at different growth stages of celery was observed. The peak of the rate of available N released from the different

organic materials was noted at 45 DAT. However, fresh wild sunflower proved to be the best for celery production followed by chicken manure, vermicompost, fresh cabbage refuse, BSU compost and the control, the last.

Conclusions

Proven from the results and findings, the following conclusions were made;

1) Application of 20 tons/ha fresh wild sunflower in situ is the best soil amendment and N source for celery production; 2) Application of different organic materials can improve the organic matter and nitrogen contents of the soil.

Recommendations

Application of 20 tons/ha fresh wild sunflower is recommended for celery production. A follow up study is also recommended to verify findings and conclusions.

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APPENDICES

Appendix Table 1. Final height per plant (cm)

TREATMENT	REPLICATION			TOTAL	MEAN
	I	II	III		
T_1	46.72	48.49	45.80	141.01	47.003
T_2	56.51	55.00	56.39	107.96	55.967
T_3	55.11	55.21	55.89	105.56	55.403
T_4	51.85	51.02	48.25	98.93	50.373
T_5	52.20	53.89	48.08	104.24	51.390
T_6	55.92	55.87	56.09	99.21	55.960
T_7	49.84	50.81	47.09	106.36	49.037
Total	368.15	369.66	357.59	1095.40	
Mean	52.59	52.81	51.08		52.162

ANALYSIS OF VARIANCE

SOURCES OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN OF SQUARES	COMPUTED F	TABULATED F .05	TABULATED F .01
Blocks	2	12.3562	6.17806			
Treatments	6	238.7442	39.7907	19.99**	3.00	4.82
Error	12	23.8896	1.9908			
Total	20	274.9899				

**- highly significant CV = 2.705 %

Appendix Table 2. Fresh weight per plant (kg)

TREATMENT	REPLICATION			TOTAL	MEAN
	I	II	III		
T_1	0.80	0.95	1.00	2.75	0.917
T_2	1.20	1.33	1.41	3.94	1.313
T_3	1.20	1.17	1.24	3.61	1.203
T_4	1.03	1.07	1.17	3.27	1.090
T_5	1.01	1.10	1.06	3.17	1.057
T_6	1.18	1.23	1.36	3.77	1.257
T_7	1.00	1.04	1.13	3.17	1.056
Total	7.42	7.89	8.37	23.68	
Mean	1.05	1.13	1.20		1.128

ANALYSIS OF VARIANCE

SOURCES OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN OF SQUARES	COMPUTED F	TABULATED F .05	TABULATED F .01
Blocks	2	0.0644	0.0322			
Treatments	6	1.3386	0.0564	29.79 **	3.00	4.82
Error	12	0.0227	0.0564			
Total	20	0.4257				

** - highly significant CV = 3.859 %

Appendix Table 3. Dry matter yield per plant 15 DAT (g)

TREATMENT	REPLICATION			TOTAL	MEAN
	I	II	III		
T_1	1.20	0.90	1.30	3.40	1.33
T_2	1.90	2.30	3.00	7.20	2.40
T_3	2.40	2.10	2.50	7.00	2.33
T_4	2.00	1.80	1.60	5.40	1.80
T_5	1.80	1.70	2.00	5.50	1.83
T_6	2.10	3.0	2.30	7.40	2.47
T_7	1.30	1.70	1.90	4.90	1.63
Total	12.70	13.50	14.60	40.8	
Mean	1.81	1.92	2.08		1.943

ANALYSIS OF VARIANCE

SOURCES OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN OF SQUARES	COMPUTED F	TABULATED F .05	TABULATED F .01
Blocks	2	0.2600	0.1300			
Treatments	6	4.2581	0.7096	6.58**	3.00	4.82
Error	12	1.2933	0.1078			
Total	20	30688.2407				

** - highly significant CV = 16.898%

Appendix Table 4. Dry matter yield per plant 30 DAT (g)

TREATMENT	REPLICATION			TOTAL	MEAN
	I	II	III		
T_1	8.90	9.40	9.60	27.90	9.30
T_2	14.20	13.00	14.40	41.60	13.87
T_3	13.00	10.80	14.00	37.80	12.60
T_4	11.00	10.30	11.20	32.50	10.83
T_5	9.40	10.00	10.30	29.70	9.90
T_6	13.00	12.50	14.90	40.40	13.47
T_7	10.60	10.00	11.00	31.60	10.53
Total	80.1	76.00	85.40	241.50	
Mean	11.44	10.85	12.20		11.500

ANALYSIS OF VARIANCE

SOURCES OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN OF SQUARES	COMPUTED F	TABULATED F .05	TABULATED F .01
Blocks	2	6.3457	3.1729			
Treatments	6	58.3733	9.7288	23.34**	3.00	4.82
Error	12	5.0009	0.4167			
Total	20	69.7200				

** - highly significant CV = 5.614 %

Appendix Table 5. Dry matter yield per plant 45 DAT (g)

TREATMENT	REPLICATION			TOTAL	MEAN
	I	II	III		
T_1	19.00	18.50	19.00	56.50	18.33
T_2	33.70	34.30	33.50	101.50	33.83
T_3	32.00	28.50	31.40	91.90	30.63
T_4	26.40	24.00	20.80	71.20	23.73
T_5	24.00	23.20	24.00	71.20	23.73
T_6	31.70	30.80	31.00	93.50	31.17
T_7	28.40	28.00	29.00	85.40	28.47
Total	195.20	187.30	188.70	571.20	
Mean	27.88	26.75	26.95		27.200

ANALYSIS OF VARIANCE

SOURCES OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN OF SQUARES	COMPUTED F	TABULATED F .05	TABULATED F .01
Blocks	2	5.0771	2.5386			
Treatments	6	501.4933	83.5822	51.15**	3.00	4.82
Error	12	19.6095	1.6341			
Total	20	527.1800				

** - highly significant CV = 4.699 %

Appendix Table 6. Dry matter yield per plant 60 DAT (g)

TREATMENT	REPLICATION			TOTAL	MEAN
	I	II	III		
T_1	32.00	30.50	32.80	95.30	31.77
T_2	54.00	55.00	52.00	161.00	53.68
T_3	53.00	52.00	49.50	153.50	51.17
T_4	41.00	38.50	44.60	124.10	41.37
T_5	38.80	37.30	41.60	117.90	39.30
T_6	55.60	48.00	51.80	153.40	51.80
T_7	45.00	44.00	48.50	137.50	45.83
Total	319.40	304.30	321.00	944.70	
Mean	45.62	43.47	45.85		44.986

ANALYSIS OF VARIANCE

SOURCES OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN OF SQUARES	COMPUTED F	TABULATED F .05	TABULATED F .01
Blocks	2	24.2600	12.1300			
Treatments	6	1142.6524	190.4421	38.96**	3.00	4.82
Error	12	58.6533	4.8878			
Total	20	1225.5657				

** - highly significant CV= 4.915 %

Appendix Table 7. Final dry matter yield per plant 70 DAT (g)

TREATMENT	REPLICATION			TOTAL	MEAN
	I	II	III		
T_1	34.00	32.00	38.00	104.00	34.67
T_2	56.00	57.40	53.80	167.20	55.73
T_3	54.80	52.00	51.00	157.8	52.60
T_4	44.00	46.80	42.90	133.70	44.57
T_5	42.80	39.00	45.00	126.80	42.27
T_6	54.60	48.00	55.00	158.60	52.53
T_7	46.30	46.40	50.00	142.70	47.57
Total	323.50	321.60	335.70	989.80	
Mean	47.5	45.94	47.95		47.133

ANALYSIS OF VARIANCE

SOURCES OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN OF SQUARES	COMPUTED F	TABULATED F .05	TABULATED F .01
Blocks	2	15.6124	7.8062			
Treatments	6	956.6467	159.4411	22.86**	3.00	4.82
Error	12	82.7076	6.9756			
Total	20	1055.9667				

** - highly significant CV = 5.604 %

Appendix Table 8. Total yield of celery (tons/ha)

TREATMENT	REPLICATION			TOTAL	MEAN
	I	II	III		
T_1	52.80	62.70	66.00	181.50	60.52
T_2	79.20	87.78	93.06	260.04	86.66
T_3	79.20	77.22	81.84	238.26	79.40
T_4	67.98	70.62	77.22	215.82	71.94
T_5	66.66	69.96	69.96	209.22	69.75
T_6	77.88	89.76	89.76	248.82	82.96
T_7	66.00	74.48	74.48	209.12	69.70
Total	489.72	520.74	552.32	1562.78	
Mean	69.96	74.39	78.90		74.42

ANALYSIS OF VARIANCE

SOURCES OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN OF SQUARES	COMPUTED F	TABULATED F .05	TABULATED F .01
Blocks	2	279.9188	139.9594			
Treatments	6	1475.7980	245.9663	29.82 **	3.00	4.82
Error	12	98.9631	8.2469			
Total	20	1854.6799				

** - highly significant CV = 3.850 %

Appendix Table 9. Soil pH 15 days after transplanting (DAT)

TREATMENT	REPLICATION			TOTAL	MEAN
	I	II	III		
T_1	5.00	4.95	4.95	14.90	4.97
T_2	4.46	4.80	4.67	13.93	4.64
T_3	4.66	5.14	4.80	14.60	4.87
T_4	4.94	5.16	5.23	15.33	5.11
T_5	5.45	5.12	5.32	15.89	5.30
T_6	5.21	4.85	4.90	14.96	4.99
T_7	4.86	5.02	4.93	14.81	4.94
Total	34.58	35.04	34.80	104.42	
Mean	4.94	5.00	4.97		4.97

ANALYSIS OF VARIANCE

SOURCESOF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN OF SQUARES	COMPUTED F	TABULATED F .05	TABULATED F .01
Blocks	2	0.0151	0.0076			
Treatments	6	0.7352	0.1225	4.12*	3.00	4.82
Error	12	0.3573	0.0298			
Total	20	1.1076				

* significant CV = 3.47 %

Appendix Table 10. Soil pH 30 days after transplanting (DAT)

TREATMENT	REPLICATION			TOTAL	MEAN
	I	II	III		
T_1	4.63	4.54	4.61	13.78	4.59
T_2	4.38	4.32	4.27	12.97	4.32
T_3	4.61	5.00	4.72	14.33	4.78
T_4	4.87	5.02	4.93	14.82	4.94
T_5	5.26	5.00	4.98	15.24	5.08
T_6	4.87	4.79	4,90	14.56	4.85
T_7	4.83	4.95	4.97	14.75	4.92
Total	33.45	33.62	33.38	100.45	
Mean	4.28	4.80	4.77		4.78

ANALYSIS OF VARIANCE

SOURCESOF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN OF SQUARES	COMPUTED F	TABULATED F .05	TABULATED F .01
Blocks	2	0.0044	0.0022			
Treatments	6	1.1489	0.1915	13.91**	3.00	4.82
Error	12	0.1652	0.0138			
Total	20	1.3185				

** - highly significant CV = 2.453 %

Appendix Table 11. Soil pH 45 days after transplanting (DAT)

TREATMENT	REPLICATION			TOTAL	MEAN
	I	II	III		
T_1	4.66	4.83	4.52	14.01	4.67
T_2	4.18	4.27	4.30	12.75	4.25
T_3	4.62	4.88	4.58	14.08	4.69
T_4	4.81	4.96	4.90	14.67	4.89
T_5	5.84	4.97	4.98	15.79	4.93
T_6	4.61	4.89	4,85	14.35	4.78
T_7	4.59	4.74	4.92	14.25	4.75
Total	32.31	33.54	33.05	98.9	
Mean	4.61	4.79	4.72		4.71

ANALYSIS OF VARIANCE

SOURCESOF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN OF SQUARES	COMPUTED F	TABULATED F .05	TABULATED F .01
Blocks	2	0.1096	0.0548			
Treatments	6	0.9038	0.1906	14.63**	3.00	4.82
Error	12	0.1236	0.0103			
Total	20	1.3170				

** - highly significant CV = 2.155 %

Appendix Table 12. Soil pH 60 days after transplanting (DAT)

TREATMENT	REPLICATION			TOTAL	MEAN
	I	II	III		
T_1	4.70	4.68	4.40	13.78	4.59
T_2	4.23	3.98	4.20	12.41	4.14
T_3	4.78	4.64	4.27	13.69	4.56
T_4	4.68	4.49	4.60	13.77	4.59
T_5	5.91	4.52	4.75	14.18	4.73
T_6	4.49	4.56	4,78	13.83	4.61
T_7	4.99	4.39	4.51	13.89	4.63
Total	32.78	31.26	31.51	95.55	
Mean	4.68	4.46	4.50		4.55

ANALYSIS OF VARIANCE

SOURCESOF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN OF SQUARES	COMPUTED F	TABULATED F .05	.01
Blocks	2	0.1893	0.0949			
Treatments	6	0.6471	0.1079	3.36*	3.00	4.82
Error	12	0.3851	0.0321			
Total	20	1.2220				

* - highly significant CV = 4.049 %

Appendix Table 13. Final soil pH

TREATMENT	REPLICATION			TOTAL	MEAN
	I	II	III		
T_1	4.72	4.62	4.49	13.83	4.61
T_2	4.45	3.96	4.28	12.69	4.23
T_3	4.81	4.67	4.28	13.76	4.59
T_4	4.72	4.37	4.80	13.89	4.63
T_5	4.86	4.55	4.83	14.24	4.75
T_6	4.58	4.60	4.86	14.04	4.68
T_7	4.96	4.83	4.58	14.37	4.77
Total	33.1	31.60	32.12	96.82	
Mean	4.72	4.51	4.58		4.61

ANALYSIS OF VARIANCE

SOURCESOF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN OF SQUARES	COMPUTED F	TABULATED F .05	.01
Blocks	2	0.1519	0.0759			
Treatments	6	0.5834	0.0972	2.79^{ns}	3.00	4.82
Error	12	0.4178	0.0348			
Total	20	1.1532				

^{ns} - not significant CV = 4.049 %

Appendix Table 14. Final organic matter content of the soil (%)

TREATMENT	REPLICATION			TOTAL	MEAN
	I	II	III		
T_1	0.97	0.87	0.81	2.65	0.883
T_2	1.48	1.42	1.46	4.36	1.453
T_3	1.62	1.64	1.68	4.94	1.646
T_4	1.80	1.74	1.76	5.30	1.766
T_5	1.48	1.50	1.52	4.50	1.500
T_6	1.54	1.48	1.50	4.52	1.506
T_7	1.68	1.70	1.64	5.02	1.673
Total	10.57	10.35	10.07	31.29	
Mean	1.57	1.47	1.43		1.490

ANALYSIS OF VARIANCE

SOURCES OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN OF SQUARES	COMPUTED F	TABULATED F .05	TABULATED F .01
Blocks	2	0.0042	0.0021			
Treatments	6	1.5134	0.2522	159.55**	3.00	4.82
Error	12	0.0189	0.0016			
Total	20	1.5366				

** - highly significant CV = 2.669 %

Appendix Table 15. Available N 15 DAT (mg/kg)

TREATMENT	REPLICATION			TOTAL	MEAN
	I	II	III		
T_1	38.46	38.89	76.09	153.44	51.15
T_2	115.38	116.66	76.08	308.12	102.71
T_3	76.08	77.77	76.08	229.93	76.64
T_4	39.77	81.39	80.45	201.61	67.20
T_5	39.77	79.54	40.22	159.53	53.18
T_6	78.65	77.77	117.97	247.39	91.46
T_7	77.77	39.32	39.77	156.86	52.29
Total	465.88	511.34	506.66	1483.88	
Mean	66.55	73.04	72.38		70.661

ANALYSIS OF VARIANCE

SOURCES OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN OF SQUARES	COMPUTED F	TABULATED F .05	TABULATED F .01
Blocks	2	178.6439	89.3219			
Treatments	6	7594.5985	1265.7664	2.52 ^{ns}	3.00	4.82
Error	12	6021.3523	501.7794			
Total	20	13794.5948				

^{ns}- not significant CV = 31.701 %

Appendix Table 16. Available N 30 DAT (mg/kg)

TREATMENT	REPLICATION			TOTAL	MEAN
	I	II	III		
T_1	37.63	76.08	74.46	188.17	62.72
T_2	155.55	192.30	186.17	534.02	178.01
T_3	117.97	77.77	153.84	349.58	116.53
T_4	79.54	79.54	80.45	297.96	79.84
T_5	79.54	78.65	39.77	197.96	65.99
T_6	76.08	155.55	114.13	345.76	115.25
T_7	116.66	116.66	78.65	311.97	103.99
Total	662.97	776.55	727.47	2166.99	
Mean	94.71	110.93	103.92		103.19

ANALYSIS OF VARIANCE

SOURCES OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN OF SQUARES	COMPUTED F	TABULATED F	
					.05	.01
Blocks	2	927.1197	463.5598			
Treatments	6	28464.8108	4744.1351	6.44**	3.00	4.82
Error	12	8845.1193	737.0933			
Total	20	38237.0498				

** - highly significant CV = 26.310 %

Appendix Table 17. Available N 45 DAT (mg/kg)

TREATMENT	REPLICATION			TOTAL	MEAN
	I	II	III		
T_1	74.46	75.26	38.88	188.60	62.87
T_2	188.17	190.21	157.17	535.55	178.52
T_3	114.13	150.53	153.84	418.50	139.50
T_4	157.30	116.66	116.66	390.62	130.21
T_5	155.55	78.65	115.38	349.58	116.53
T_6	153.84	155.55	116.66	426.05	142.02
T_7	153.84	114.13	152.17	420.14	140.05
Total	997.29	880.99	850.76	2729.04	
Mean	142.47	125.85	125.85		129.954

ANALYSIS OF VARIANCE

SOURCES OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN OF SQUARES	COMPUTED F	TABULATED F .05	TABULATED F .01
Blocks	2	1710.0278	885.0139			
Treatments	6	22133.6879	3688.9479	6.47**	3.00	4.82
Error	12	6844.5250	570.3771			
Total	20	30688.2407				

** - highly significant CV = 18.378%

Appendix Table 18. Available N 60 DAT (mg/kg)

TREATMENT	REPLICATION			TOTAL	MEAN
	I	II	III		
T_1	37.63	38.04	37.23	112.90	37.63
T_2	75.26	114.13	37.63	227.02	75.67
T_3	76.08	75.26	76.08	227.42	75.81
T_4	76.92	112.90	38.04	227.86	75.95
T_5	76.92	38.88	38.46	154.26	51.42
T_6	77.77	38.46	38.88	155.11	51.70
T_7	38.04	77.77	38.46	154.27	51.42
Total	458.62	495.44	304.78	1258.84	
Mean	65.51	70.77	43.57		59.945

ANALYSIS OF VARIANCE

SOURCES OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN OF SQUARES	COMPUTED F	TABULATED F .05	TABULATED F .01
Blocks	2	2922.5568	1461.2784			
Treatments	6	4398.8089	733.1348	1.51^{ns}	3.00	4.82
Error	12	5844.0788	487.0065			
Total	20	13165.4445				

^{ns}- not significant

CV = 36.814 %

Appendix Table 19. Final available N content of the soil (mg/kg)

TREATMENT	REPLICATION			TOTAL	MEAN
	I	II	III		
T_1	37.63	37.63	38.04	113.30	37.77
T_2	75.26	74.46	75.26	224.98	74.99
T_3	76.92	38.46	38.46	153.84	51.28
T_4	75.26	75.46	75.26	225.98	75.33
T_5	75.26	75.26	37.63	188.15	62.72
T_6	76.08	38.46	38.46	153.00	51.00
T_7	38.46	38.04	76.08	153.88	50.86
Total	454.87	377.77	379.19	1211.83	
Mean	64.98	53.96	54.17		57.706

ANALYSIS OF VARIANCE

SOURCES OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN OF SQUARES	COMPUTED F	TABULATED F .05	TABULATED F .01
Blocks	2	555.8995	277.9497			
Treatments	6	3495.4656	528.5776	2.14 ^{ns}	3.00	4.82
Error	12	3272.4620	272.7052			
Total	20	7323.8271				

^{ns}- not significant

CV = 28.617 %