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PRODUCTIVITY OF BROCCOLI (*BRASSICA OLERACEAE* L.) UNDER ORGANIC SOIL AMENDMENTS

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ABSTRACT
The current strategy of using organic soil amendments as a sustainable means of soil fertility restoration and for increase in yields of broccoli (*Brassica oleraceae* var. Legacy) planted on marginal soils stimulated positive response in plant height, curd diameter, weight per curd, marketable and non-marketable yields, pH, organic matter, P, K levels and return on investment as observed under screen house in 2016 and 2017 seasons at the vegetable Crops nursery of the Institute of Crops Science University of the Philippines Los Banos, Laguna 4031. The treatments consisted of four organic soil amendments (composted chicken manure, mushroom compost, composted horse manure and vermicompost) applied at the rate of 6 tons/ha and a control. These were combined to give five treatments combination and laid out in a Randomized Complete Block Design replicated thrice. Results showed a significant effect of all the applied organic soil amendments in the two years of study on all the parameters recorded. However, composted chicken manure significantly gave the tallest height, heaviest curd, largest curd diameter, heaviest weight per curd, marketable and non-marketable yields, increased in pH, highest organic matter, P and K levels and highest return on investment of 179.42% higher than other treatments and the control in both years. It can be concluded based on this results that a clear proof of the compatible synergism of broccoli with the four organic soil amendments used had been established as a veritable means of sustainable broccoli production and marginal soil fertility restoration and management technique. It also recommends vegetable crop farmer to use decompose chicken manure level of 6 t/ha in combination with broccoli variety legacy in order to obtain higher broccoli yield, restore fertility of marginal soils for higher net profit and returns on investment in the study area.

Keywords: Fertility, Health, Potassium, pH, Phosphorus, Marginal soil, Sustainability, Yield.

INTRODUCTION
Broccoli (*Brassica oleraceae* L. var. legacy) is considered a high value vegetable due to its relative importance to human health and the economy of farmers involved in its production. Broccoli constitutes about 36% percent of the vegetable crops that are found daily on display for sale in Metro Manila markets (Aquino, 2012). High value vegetables such as broccoli are good sources of vitamins and minerals and contain antioxidants which are important for good health, being rich in calcium, folic acid, selenium, potassium, vitamins A and C (Jahangir *et al*., 2009), anticarcinogenic properties, bowel cleansing by the presence of glucosinolates and photochemical products that offer an extra protection against heart disease (Rosa and Rodrigues, 2001; Keck and Finley, 2004 and Baenas *et al*., 2012). The total volume of production of this crop in the Philippines in the year 2015 stood at 1,959.63 MT from a

cultivated area of 184.75/ ha (Bas, 2011). However, vegetable crops farmers are striving vigorously to increase their production output per unit area for higher yield and income due to the rapid geometrical population increase brought about by the growing consciousness among the populace of the benefit of healthiness and wellness which are key to healthy living and longevity.

There is an increased daily demand for organically produced vegetable crops as a result of a growing awareness of possible adverse environmental, health and economic impacts of agrochemicals on vegetable crops production couple with increases in production failing to keep up with daily demand has stimulated interest in the greater utilization of organic soil amendments for restoring fertility, rejuvenating, maintaining the soil and fertilizing vegetable crops to achieved an increased in marketable yield. Organically grown high value vegetables occupy a major part of the fresh produce industry that has experienced strong growth in the 1990s (Olusola, 2002). Making up an estimated $4 billion in sales in 2000 (PMA, 2000), as of then, the organic produce industry was projected to have an increase of 7% annually in sales owing to the consumers demand for safe, healthy, flavorful alternatives for their diets (Olusola, 2002).

There is a considerable potential to maintain, increase and improve the quality and yield of high value vegetable crops such as broccoli through improved cultural practices like the use of organic soil amendments (Batt *et al.,* 2008). Organic soil amendments are any organic material added and mixed with the soil in order to increase and maintain the soil fertility by improving the chemical and physical properties of the soil for the benefit of the crops (Arancon *et al.,* 2006b). The application of organic amendments do stimulate the natural cycles that ameliorate and enrich the soil where nutrients are released over time for crop growth and development (Snyder, 2009). Organic soil amendments increases the soil water holding capacity, improved soil aeration and water infiltration into the soil (Davis and Wilson, 2012). Organic farming preserves and enhances fertility of the soil because it encourages the activity of beneficial soil inhabiting microorganisms and minimizes flow of toxic agrochemicals into waterways, besides, the soil and ecosystem is maintained healthy while producing safe vegetables for consumption (Abdel *et al*., 2004). Building up or nourishing the soil with the use of organic soil amendments is the major concept of organic farming which is highly sustainable strategy (Stephens and Kostewicz, 2009).

Organic soil amendments contain plant growth regulating materials, plant growth hormones and humic acids all of which have been found to induced germination, growth and yields of several plants (Atiyeh *et al.,* 2002). However, the production of high value vegetable crops such as broccoli through the use of organic soil amendments is one among many cultural practices that would improve quality of produce and at the same time improve the soil chemical and physical structure and maintain a healthy environment for the future generations yet unborn. However, adopting organic vegetable crop production systems with low inputs will provide greater food security for rural and urban families and are socially and environmentally more sustainable (Altieri, 2002).

Therefore, the objective of this study is to determine the best among the organic soil amendments; assess their effects on broccoli growth and yield, soil pH, soil organic matter content, Phosphorus (P) and Potassium (K); compared to costs and returns for the production of broccoli using the organic soil amendments mentioned.

MATERIALS AND METHODS

The Study Area

The study was conducted at the vegetable crops nursery of the Institute of Crops Science University of the Philippines Los Banos, College Laguna 4031, over two seasons from 12th January to 12th March of 2016 and 2017 to study the Productivity of broccoli (*brassica oleraceae* L.) under organic soil amendments. Broccoli *(Brassica oleraceae* variety legacy) was sown into nursery beds under screen house and transplanted at three-to-four leaves stages to already prepared permanent growing beds outside the screen house. A composite soil samples of each replicate were collected before applying the organic soil amendments and after termination of the study from a depth of 15 - 20 cm and analyzed for pH, organic matter, phosphorus, potassium and cation exchange capacity (CEC) in the Analytical laboratory of the Institute of Chemistry University of the Philippines Los Banos, College Laguna 4031.

Experimental Design

Results of soil analysis characterize the soil samples as clay loam with pH 5.50 and 5.13, organic matter 0.20 and 0.19 g/kg, available P 5.76 and 6.00 g/kg, K 0.30 and 0.31 Cmol/kg soil. Total field size was 100 square meters, total bed at the rate of 6 t/ha one week before transplanting and sowing, respectively. However, all important cultural and management practices such as weeding, watering and hilling-up were carried out when necessary.

Data Collection and Analysis

Data were collected on broccoli plant height (cm), curd diameter (cm), weight per curd (g), marketable and non-marketable yield (kg/plot), incidence of insect pests and diseases during the cropping period. All data collected were analyzed using the equation of Chapman and Ayrey (1981) in variance of randomized complete block design in three replicates. Mean difference were determined using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Results in Table 1 showed that there were significant differences between the four organic soil amendments and the control. However, no significant differences were noticed among the organic soil amendments applied, even though, decomposed chicken manure had a slightly higher plant height than the other organic soil amendments in both years. Similar trend was obtained in curd diameter where significant differences occurred between the four organic soil amendments and the control, decomposed chicken manure, though not statistically significant, gave higher values than the other organic soil amendments during the two years of the study. There were significant differences among organic soil amendments for weight per curd in both 2016 and 2017. Decomposed chicken manure had a higher weight per curd than the other organic soil amendments in the two years; control had generally the least weight per curd. The effect of the organic soil amendments on broccoli plant height, curd diameter and weight per curd could be attributed to number of nutrients elements present in the organic soil amendments particularly the macro element such as nitrogen, phosphorus and potassium whose released add more of these nutrients elements to the soil. The result of this finding is in line with that of Buckerfield *et al*. (1999) and Subler *et al.* (1998) that organic soil amendment contains all the essential nutrients required for crop production.

The use of organic soil amendments in vegetable crop production is on the increase in view of the high price of mineral fertilizers and the difficulty in procuring it at the required time (Lerch *et al.,* 1990). Organic soil amendments can also increase the water infiltration rates of soil by improving the soil structure (Snyder, 2009) further reported that poultry manure is the most valuable of all manures produced by livestock and that it has historically been used as a source of plant nutrients for soil amendment.

Among organic soil amendments, decompose chicken manure when applied correctly increases the fertilizer use efficiency and improve the physical and chemical properties of soil (Mondal *et al*., 1990; Sharma *et al*., 1990; Salim *et al*., 1997 and Rashid *et al.,* 1999). Okonkwo and Chibuzo (2000) reported that the effect of application of 6.4 t/ha and 6.8 t/ha of decomposed chicken manure was found to be superior to cow dung as a source of nutrient for potato production. Giardini *et al*. (1992) were of the view that the effectiveness of decompose chicken manure depends on its composition, environmental conditions and the crop characteristics. Ingrid (2004) stated that, nutrient contents of decompose chicken manure is among the highest of all animal manures, its use as organic soil amendment for agricultural crops will provide appreciable quantities of all important plant nutrients.

Table 1: Plant height, Curd Diameter and Weight per Curd as affected by Organic Amendments

Treatment	**Plant height (cm)**		**Mean**	**Curd diameter (cm)**		**Mean**	**Weight per curd (g)**		**Mean**
	2016	**2017**		**2016**	**2017**		**2017**	**2016**	
Control	15.45[b]	24.97[b]	20.06[b]	6.29[bc]	9.97[b]	8.13[b]	179.1[d]	150d	164.58[cd]
Chicken manure	20.16[a]	26.90[a]	23.53[a]	9.90[a]	11.5[a]	10.97[a]	312.83[a]	300[a]	306.42[a]
Mushroom compost	18.60[a]	26.07[a]	22.34[a]	7.25[b]	10.8[a]	9.06[a]	225.2[b]	200[b]	212.61[b]
Horse manure	17.73[a]	26.50[a]	22.30[a]	6.96[b]	11.3[a]	10.65[a]	199.36[c]	190b[c]	194.68[c]
Vermicompost	18.36[a]	27.23[a]	22.80[a]	7.05[b]	11.2[a]	9.16[a]	190.9[d]	180[c]	185.45[c]
LS	**	**	**	**	**	**	**	**	**
CV (%)	13.64	19.67	17.65	3.53	5.75	5.25	2.91	14.14	4.26

Means with the same letter in a column are not significantly different at 5% level by DMRT.
pH level, organic matter, phosphorus and potassium content

Table 2 presents the results of soil analysis of the experimental site before the experiment. The soil is slightly acidic (pH 5.5 and 5.13), low in organic matter, phosphorus and potassium. However, after the application of all the organic soil amendments during the period of the study, values recorded indicated that pH level was changed to neutral (increase), there was a significant increase in phosphorus and potassium content of the soil and decomposed chicken manure produced the highest means in the two years of study (Table 2). This might be ascribed to the flocculating, aggregating and conditioning role of the applied organic soil amendments because ammonium-N (NH_4-N) is a significant part of total N in decomposed chicken manure, which additionally contains uric acid which metabolizes rapidly to NH_4-N in most soils, and the net result of high NH_4-N and uric acid contents in decomposed chicken manure waste is that a large percentage of N can be converted to nitrate-N (NO_3-N) (Sims and Wolf, 1994) as Brassica crops tends to be more productive when grown on soils having approximately neutral pH and the ideal pH is 5.8-to-6.5 for mineral and organic soils (Dixon, 2006). High amounts of ammonia may be lost if decomposed chicken manure is surface applied and therefore should be mixed or incorporated with and into the soil immediately (Schilkey-Gartley and Sims, 1993; Chambers *et al*., 2000). Meanwhile, availability of these organic elements to broccoli will enable the crop absorbed much of phosphorus and potassium for root and curd development considering the initial pH, organic matter, phosphorus and potassium content of the soil.

Table 2: pH Level, Organic matter, Phosphorus and Potassium content of the Soil Planted to Broccoli as affected by Organic Soil Amendments

Treatment	pH		OM (g/kg)		P (g/kg)		K (Cmol/kg)	
	2016	2017	2016	2017	2016	2017	2016	2017
Control	4.09	5.00	0.20	0.23	5.60	6.02	0.30	0.33
Chicken manure	6.08	6.49	2.25	3.00	6.05	6.90	0.34	0.35
Mushroom compost	5.44	5.47	1.50	1.70	5.55	5.80	0.30	0.33
Horse manure	5.06	5.07	1.00	1.42	5.90	6.06	0.31	0.32
Vermicompost	5.90	5.98	1.98	2.00	6.00	6.04	0.32	0.33
Initial analysis	5.50	5.13	0.20	0.19	5.76	6.00	0.30	0.31

Application of any of the known organic soil amendments increased the growth, yield and water use efficiency of crops (Sushila and Gajendra, 2000). Decompose chicken manure is a valuable source of plant nutrients, it contains easily degradable compounds and by virtue of their low carbon and nitrogen ratio it is readily biodegraded when added to soil under conducive conditions of temperature and soil moisture (Chambers *et al.,* 2000). Moreover, the concomitant release of CO_2 with the nutrient elements during microbial decomposition is an indication of promising mineralization rates (Abdel Magid *et al*., 1994). Decompose chicken manure are mostly uniform in physical appearance and rich in fibre, ammonia nitrogen and moisture (Georgakakis and Krintas, 2000). Therefore, the significant effect of all the applied organic soil amendments on this parameters showed that organic soil amendments is a supplier of N, P and K in the soil which also increases the phosphate solubilizing bacteria in the rhizosphere (Bababe *et al*., 1998) thereby increasing the absorptive capacity of the broccoli crop roots, further indicating that decomposed chicken manure is the richest of all farmyard manure and contained higher nitrogen, P_2O_5, K_2O and small amount of fibres and contains all the essential nutrient elements required by plants for optimum growth and yield (Madder *et al*., 2002).

Marketable and Non-marketable Yield

There were significant differences among organic soil amendments in terms of marketable yield, and differences were consistent across treatments in both years (Table 3). Decomposed chicken manure had the highest marketable yield. Mushroom compost came second but its difference from other treatments was only slight (2 t/ha). Regardless of type of treatment, decomposed chicken manure and mushroom compost gave higher marketable yield compared with other soil amendments and the control (Table 3). For non-marketable yield, the same trend as marketable yield was observed. Decomposed chicken manure had the highest non-marketable yield followed by mushroom compost in 2016 only; however, a non-significant difference was recorded on non-marketable yield of broccoli in 2017. The significant differences observed indicated a more efficient use of nutrients released by the organic soil amendments by broccoli roots owing to their availability within the root zone for timely absorption, translocation and utilization. Organic soil amendments are multinutrient products that can supply primary, secondary and micronutrients, it also improves the structure of the soil, enhance water retaining capacity and create favorable conditions for the growth of several soil organisms that are friendly to crop production (Singh, 2002).

Organic soil amendments mainly composed of wastes and residues from plants and animal that supply some nutrients for plants and carbon containing compounds serve as food for microorganisms (Madder *et al*., 2002). Wang *et al.* (2001) reported that soil organic manure improves the structure of the soil directly through their action as bulky diluents in compacted soils or indirectly when the waste products of animals or micro-organisms cement soil particles together thereby improving the soil structure and increases the amount of water available to the crops.

The application of organic soil amendments also improves aeration and drainage and also encourages good root growth by providing enough pores of the right sizes, thus preventing the soil from becoming too rigid when dry or completely waterlogged and devoid of air when wet (Martin-olmedo and Rees, 1999). The application of organic sources of nutrients, such as decomposed chicken manure to soil is a current environmental and agricultural practice for maintaining soil organic matter, reclaiming degraded marginal soils and supplying plant nutrients (Ouedraogo *et al*., 2001).

Table 3: Marketable and Non-marketable Yield of Broccoli as affected by Organic Soil Amendments

Treatment	Marketable yield (t/ha)		Mean	Non-marketable yield (t/ha)		Mean
	2016	2017		2016	2017	
Control	10.75[d]	8.52[c]	9.64[c]	1.05[c]	0.30[a]	0.68[ab]
Chicken manure	18.77[a]	17.45[a]	18.11[a]	1.86[a]	0.42[a]	1.14[a]
Mushroom compost	13.51[b]	11.33[b]	12.42[b]	1.40[b]	0.40[a]	0.90[a]
Horse manure	11.96[c]	10.99[bc]	11.48[b]	1.66[b]	0.48[a]	1.07[a]
Vermicompost	11.45[c]	10.88[bc]	11.17[b]	1.48[b]	0.35[a]	0.92[a]
LS	**	**	**	**	NS	NS
CV (%)	3.9	6.59	5.25	2.53	20.98	11.17

Means with the same letter in a column are not significantly different at 5% level by DMRT, NS = Not significant at 5 % level of probability.

Cost and Return Analysis

This revealed a positive return in all the organic soil amendments applied where yield data was taken. However, decomposed chicken manure gave the highest rank in net returns (272,900) and return on investment (ROI %) of 179.42% indicating that it is more economical to use in broccoli production than the other organic soil amendments and control (Table 4). Apart from monetary returns on investment, other benefits such as improvement of the soil structure in the study site can be achieved, as sustainable application of the right organic soil amendments is known to improve soil structure, as it is fundamental in sustainable agriculture (Lampkin, 1990).

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Table 4: Total production Cost, Gross returns, Net profit and Return of Investment of Broccoli

Treatments	Total Production Cost	Yield (kg/ha) Less 10% spoilage & price fluctuation (Php25/kg)	Gross return (Php)	Net Profit (Php)	Return of investment (ROI %)
No fertilizer	132,100	8,680	217,000	84,900	64.27
Chicken manure	152,100	17,000	425,000	272,900	179.42
Mushroom compost	148,100	11,180	279,500	131,400	88.72
Horse manure	151,300	10,330	258,250	103,600	70.69
Vermicompost	182,100	10,050	251,250	69,150	37.97

Php = Philippines peso.

Organic soil amendments increase the nutrient status of a soil, which leads to increase in yield of crops (Hatchet, 1987). The work of Muhammad *et al.* (2005) on the effect of organic soil amendments and inorganic fertilizer on growth and yield of rice found that, among organic sources of nutrient applied, decomposed chicken manure at 20 t/ha gave higher benefit cost ratio (BCR) value of 1:69 than that of farm yard manure at 20 t/ha which had a benefit cost ratio of 1:45. When decomposed chicken manure was applied under field conditions at 8.2 t/ha organic carbon mineralization of 50% was obtained (Abdel Majid *et al.,* 1993) and that further increase beyond 8.25t/ha is not advisable and may lead to unnecessary monetary losses.

Soil fertility is a dynamic concept which is influenced by climate and cultural practices (Abdel *et al*., 2004). Organic soil amendments affect plant growth and yield by improving the physical and chemical properties of the soil which in turn influence growth and yield (Azad *et al.*, 1998). Organic soil amendments has potential to supply most of the nitrogen and sulphur and half of the phosphorous taken up by crops from the soil and also supply most of the cation exchange capacity (CEC) of acidic and highly weathered soils. Organic soil amendments are a more complete plant food as opposed to inorganic fertilizers because they provide almost all the essential nutrients as well as trace elements and restores the pH of soils which have become acidic due to heavy use of chemical fertilizers (Lerch *et al*., 1990).

Benefits derivable from organic soil amendments are improved soil physical properties when applied to heavy or sandy soils and the fibrous portion of the organic soil amendments having high carbon content promotes soil aggregation which in turn improved the permeability and aeration of clay soils and the ability to absorb moisture which also helps in the granulation of sandy soils and consequently improves the soil water holding capacity (Moore *et al.,* 1995). Organic solid waste simultaneously contributes to the physicochemical and nutritional aspects of soil fertility in addition to supplying major nutrients particularly N, P, K and some micro-nutrients (Sorensen *et al.,* 1998). Application of decomposed chicken manure and sunflower residue as form of organic soil amendments produced high reduction in macro pores values and the highest increase in micro pores at the same time and that organic residues addition to loamy sand soil significantly changed bulked density and soil pores size distribution especially micro pores in a positive direction towards maximizing the ability of loamy sand soil to retain and conserve irrigation water against rapid loss by percolation and that addition of organic wastes to loamy sand soil gradually increased soil water retention at both 0.1 and 15 bars which represent field capacity and permanent wilting point (Shaaban, 2006).

Sludge organic matter and organic compost enhance soil water retention capacity as a result of modifying its bulk density and soil porosity (Shaaban, 2006; Clark *et al.*, 2000; Kay, 1998 and Gregorrich *et al.*, 1997). Treating sandy soil with organic manure decreased macro pores which increased micro pores and as a result hydraulic conductivity decreased and more reduction was obtained by increasing the application rates (Kotb, 1994). After 4 years, yields were higher in farms with a history of organic management than in conventional farms. Therefore, medium to long-term organic management positively affects crop productivity (Bulluck *et al.,* 2002).

CONCLUSION AND RECOMMENDATIONS

The results of this study however showed that, application of all the organic soil amendments at 6 t/ha significantly affected all the observed parameters of broccoli crop, soil organic matter content, soil pH, P and K levels, net profit and returns on investment observed, decomposed chicken manure significantly produced highest growth and yield means, soil organic matter content, soil pH, P and K levels, net profit and returns on investment means. Generally, the performance of broccoli when subjected to varying organic soil amendments at 6 t/ha, was better and higher under decomposed chicken manure during the two seasons, compared to other treatments and the control. Based on the result of this study, the following recommendations were made:

1. The use of decomposed chicken manure at the rate of 6 t/ha in combination with broccoli variety legacy by vegetable crop farmers in the study area in order to obtain higher broccoli yield, restore fertility of marginal soils and higher net profit and returns on investment.
2. Further research on marginal soil fertility restoration and broccoli crop production using these organic soil amendments or other organic soil amendments as source of nutrient is also recommended.

REFERENCES

Abdel Magid, H. M., Sabrah, R. A. A., Rabie, R. K., ElNadi, A. H. and Abdel-Aal, Sh. I. (1993). Biodegradation of municipal refuse and chicken manure in a winter wheat ecosystem in Saudi Arabia. *Journal of Arid Environments*, **25**: 411-420.

Abdel Magid, H. M; Sabrah, R. E. A; ElNadi, A. H; Abdel – Aal, Sh. I. and Rabie, R. K. (1994). Kinetics of biodegradation rates of chicken manure and municipal refuse in sandy soil. *Journal of Arid Environments*, **28**: 163-171.

Abdel, S. H., Ahmed, H., Mahmoud, F. A., Hamid, O. B. and Faisal, E. A. (2004). Effect of Nitrogen levels on growth and yield of wheat at different elevations under rainfed conditions in Jeba marra highlands. *Journal of Agriculture and Biology*, **4**: 99-111.

Altieri, M. (2002). Agroecology: the science of natural resource management for poor farmers in marginal environments. *Agriculture Ecosystem and Environment*, **93**: 1-24.

Aquino, C. (2012). *The Philippine vegetable industry almost comatose.* (Online) Available: www.focusonpoverty.org

Arancon, N.Q., Edwards, C.A., Lee, S., Byrne, R. (2006b). Effects of humic acids from vermicompost on plant growth. European Journal of Soil Biology, **46**, 65–69.

Atiyeh, R.M., Lee, S., Edwards, C.A., Arancon, N.Q., Metzger, J.D. (2002). The influence of humic acids derived from earthworms-processed organic wastes on plant growth. *Bioresource Technology*, **84**: 7–14.

Azad, B. S., Gupta, S. C. and Peer, A. C. (1998). Influence of organic and inorganic fertilizers in maximizing wheat yield at irrigated condition. *Environment and Ecology*, 16: 71-73.

Baenas, N., D. Moreno, and Garcia-Viguera, V. (2012). Selecting sprouts of brassicaceae for optimum phytochemical composition. *Journal of Agriculture and Food Chemistry*, **60**: 11409-11420.

Bas, L.Q. (2011). *Situation on highland vegetables*. Bureau of Agricultural Statistics. Baguio City, Philippines.

Bababe, B., Sandabe, K. M. and Ibrahim, A. (1998). *The use of organic waste and compost as an alternative source of fertilizer in Borno State.* A paper presented at a workshop on soil fertility management and utilization of organic wastes at the Borno State Agricultural development programme (BOSADP) Maiduguri, Pp. 81-88.

Batt, P. J., Conception, S., Dagupen, K. and Prior, R. M. (2008). T*he vegetable industry in the Philippine.s* (Online) Available: http://www.aciar.gov.au/system/files/sites.

Buckerfield, J. C., Flavel, T., Lee, K. E., Webster, K. A. (1999). Vermicompost in solid and liquid form as plant growth promoters. *Pedobiologia,* **43**: 753–759.

Bulluck, L. R., Brosius, M., Evanylo, G. K. and Ristaino, J. B. (2002). Organic and synthetic fertility amendments influence soil microbial, physical and chemical properties on organic and conventional farms. *Applied Soil Ecology,* **19**: 147-160.

Chapman, J. M. and Ayrey, C. (1981). *The use of Radioactive Isotopes in the Life Science*. George Allen and Unwin Ltd, London.

Chambers, B. J., Smith, K. A. and Pain, B. F. (2000). Strategies to encourage better use of nitrogen in animal manure. *Soil use management*, **16**: 157-161.

Clark, G. A., Stanlay, C. D. and Maynard, D. N. (2000). Municipal solid waste compost (MSWC) as a soil amendment in irrigated vegetable products. *Transactions of the ASAE*. **143**: 847-853.

Davis, J. G. and Wilson, C. R. (2012). *Choosing a soil amendment.* Colorado State University Extension. (Online) Available: www.ext.colostate.edu/Garden/07235.html.

Dixon, G. R. (2006). *Vegetable Brassicas and Related Crucifers: In: Crop Production*, Science in horticulture series 14. CABI Nosworthy way, Wallingford, Oxfortshire OX108DE, UK. Pp. 13-67.

Georgakakis, D. and Krintas, T. (2000). Optimal use of the Hosoya system in composting poultry manure. Bioresource. Technology; **72**: 227-233.

Giardini, L., Pimpini, F., Borin, M. and Gianquinto, G. (1992). Effects of poultry manure and mineral fertilizers on the yield of crops. *Journal of Agricultural Science* Cambridge, **188**: 207-213.

Gregorrich, E. G., Carter, M. R., Doran, J. W., Pankhurst, C. E. and Dwyer, L. M. (1997). Biological attributes of the quality. In: Gregorrich, E. G; and Carter, M. R; (Eds) soil quality for crop production and ecosystem health. Elsevier, Amsterdam, the Netherlands, Pp: 81-113.

Hatchet, S. S. (1987). Productivity of wheat varieties, as influenced by the time of sowing. *Journal of Research*, Punjab Agriculture University, **18**: 227-233.

Ingrid, K. T. (2004). Nitrogen use efficiency of ^{15}N-labeled poultry manure. *Soil Science of American Journal,* **68**: 538-544.

Jahangir, M., H. Kim, Y. Choi, and R. Verpoorte. (2009). Health affecting compounds in Brassicaceae. *Comprehensive Review on Food Science*, **8**: 31-43.

Kay, B. D. (1998). *Soil structure and organic carbon: A review*. **In**: Lal, R., Kimbe, J. M., Follett, R. F. and Steward, B. A. (Eds) soil processes and the carbon cycle. CRC press, Boca Raton, Florida, Pp. 169-197.

Keck, A. Finley, and J. (2004). Cruciferous vegetables: Cancer protective mechanisms of glucosinolates hydrolysis products and selenium. *Integrated Cancer Therapy*. **3**: 5-12.

Kotb, M. T. A. (1994). *Soil and water management practices for some crops production.* Ph.D. Thesis, Faculty of Agriculture; Zagazig University, Egypt, Pp. 269-283.

Lampkin, N. H. (1990). *Organic Farming*. Farming Press Books. United Kingdom. 701Pp.

Lerch, R. N., Babarick, K. A., Westall, D. G. and Follett, R. H. (1990). Effect of different rates of sewage sludge for sustainable dry land winter wheat production. *American Soil Science Society*, **3**: 66-71.

Martin-Olmedo, P. and Rees, R. M. (1999). Short term N availability in response to dissolved organic-carbon from poultry manure alone or in combination with cellulose. *Biology and Fertility of Soils,* **29**: 386-393.

Madder, P., Fliebbach, A., Dubois, D., Gunst, L., Fried, P. and Niggli, U. (2002). Fertility and biodiversity in organic farming. *Science,* **296**: 1694-1697.

Mondal, S., Joyaram, D. and Pradhan, B. K. (1990). Effect of fertilizer and FYM on the field and yield components of rice. *Environment and Ecology*, **8**: 23-36.

Moore, P. A. Jr., Daniel, T. C., Sharpley, A. N. and Wood, C. W. (1995). Poultry manure management: Environmentally sound options. *Journal Soil and Water Conservation*, **50**: 321-327.

Muhammed, U., Ehsan, U., Ejaz, A. W., Muhammad, F. and Amir, L. (2005). Effect of organic and inorganic manures on growth and yield of rice variety "Basmati – 2000" *International Journal of Agriculture and Biology,* **4**: 481-483.

Okonkwo, J, C. and Chibuzo, A. C. (2000). Complementary effects of poultry manure and inorganic fertilizers on the field performance of irrigated wheat/potato intercrop in Jos, Plateau, Nigeria. *Agriculture Journal*, **31**: 49-56.

Ouedraogo, E., Mando, A., Zombre, N. P. (2001). Use of compost to improve soil properties and crop productivity under low input agricultural system in West Africa. *Agricultural Ecosystem and Environment*, **84**: 259-266.

Olusola, L. (2002). *Fresh-cut Fruits and Vegetables Science, Technology and Market.* CRC Press LLC, 2000 N.W. Corporate Blvd., Boca, Florida 33431, USA. Pp. 31- 65.

Produce Marketing Association (PMA) (2000). *Retail Fresh Produce Industry Sales and Industry*. Overview: Foodservice. Newark, DE.

Rashid, M., Yasmin, N., Shakir, M. Y. and Saleem, Z. (1999). Effect of integrated use of manures and fertilizers on rice and wheat yield. *Pakistan Journal of Agricultural Research,* **37**:167-74.

Rosa, E. and A. Rodrigues. (2001). Total and individual glucosinolates content in 11 broccoli cultivars grown in early and late seasons. *HortScience,* **36**: 56-59.

Salim, M., Ullah, R., Niazi, B. H. and Zaman, B. (1997). Integrated plant nutrient system in Pakistan. Conceptional approach paper presented at training course on efficient use of fertilizer. Organized by NFCD. October, 20^{th}-24^{th}. Pp 380 -397.

Schilkey-Gartley, K. L. and Sims, J. T. (1993). Ammonia volatilization from poultry manure – amended. *Soil Biology, Fertilizer and Soils,* Pp. 165-172.

Shaaban, S. M. (2006). Effect of organic and inorganic nitrogen fertilizer on wheat plant under water regime *Journal of Applied Science Research,* **2**(10): 650-656.

Sharma, A. R. and Mitra, B. N. (1990). Complementary effect of organic bio and mineral fertilizers on rice based cropping system. *Fertilizer News*, **32**: 43-51.

Sims, J. T. and Wolf, D. C. (1994). Poultry waste management: Agriculture and environmental issues. A*dvanced Agronomy*, **52**: 2-83.

Stephens, J. M. and Kostewicz, S. R. (2009). *Producing garden vegetables with organic soil amendments.* Horticultural Sciences Department. Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville FL 32611.

Subler, S., Edwards, C. A. and Metzger, J. (1998). Comparing vermicompost and composts. *BioCycle*. **39**: 63–66.

Sushila, R. and Gajendra, G. (2000). Influence of farmyard manure, nitrogen and bio-fertilizers on growth – yield attributes and yield of wheat under limited water supply. *Indian Journal of Agronomy*, **45**: 590-595.

Snyder, M. (2009). *Organic vegetable gardening blog-organic gardening tips and ideas. Canadian Journal of Soil Science,* **86**: 20-29.

Singh, H. B. (2002). The role of manures and fertilizers in crop production. Developing Alternative-input in Nigeria (DAIMINA). An IFDC, USAID, and FGN publication. Pp. 18-36.

Sorensen, P. and Jensen, E. S. (1998). The use of ^{15}N labeling to study the turnover and utilization of ruminant manure N. *Biology, Fertility and Soils,* **28**: 56-63.

Wang, X., Dianxiong, C. A. I. and Zhang, J. (2001). *Land application of organic and inorganic fertilizer for corn in dry land farming region of North China.* Scientific content, pages 419-422. *Sustaining the Global farm*. Selected papers from the 10th international soil conservation organization meeting held May 24-29th, 1999 at Purdue University and USDA-ARS National soil Erosion Research Laboratory.