This article was downloaded by: *[Universidad Publica de Navarra]*
On: *16 May 2011*
Access details: *Access Details: [subscription number 936140347]*
Publisher *Taylor & Francis*
Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK

Journal of Plant Nutrition
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713597277

IMPACT OF INTEGRATED NUTRIENT MANAGEMENT ON TOMATO YIELD QUALITY AND SOIL ENVIRONMENT

Sadaf Javaria[a]; M. Qasim Khan[a]
[a] Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan

Online publication date: 01 December 2010

To cite this Article Javaria, Sadaf and Khan, M. Qasim(2011) 'IMPACT OF INTEGRATED NUTRIENT MANAGEMENT ON TOMATO YIELD QUALITY AND SOIL ENVIRONMENT', Journal of Plant Nutrition, 34: 1, 140 — 149
To link to this Article: DOI: 10.1080/01904167.2011.531605
URL: http://dx.doi.org/10.1080/01904167.2011.531605

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: http://www.informaworld.com/terms-and-conditions-of-access.pdf

This article may be used for research, teaching and private study purposes. Any substantial or systematic reproduction, re-distribution, re-selling, loan or sub-licensing, systematic supply or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

Journal of Plant Nutrition, 34:140–149, 2011
Copyright © Taylor & Francis Group, LLC
ISSN: 0190-4167 print / 1532-4087 online
DOI: 10.1080/01904167.2011.531605

IMPACT OF INTEGRATED NUTRIENT MANAGEMENT ON TOMATO YIELD QUALITY AND SOIL ENVIRONMENT

Sadaf Javaria and M. Qasim Khan
Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan

Downloaded By: [Universidad Publica de Navarra] At: 09:53 16 May 2011

□ *Sustainable agricultural production incorporates the idea that natural resources should be used to generate increased output and incomes, especially for low income groups without depleting the natural resource base. Integrated nutrient management (INM) integrates the use of all natural and man- made sources of plant nutrients, so that productivity and nutrient status of food increases in an efficient and environmentally benefiting manner without sacrificing soil productivity of future generations. Integrated nutrient management relies on a number of factors including appropriate nutrient application and conservation and the transfer of knowledge about INM practices to farmers through extension personal. Tomato is the most popular home garden and the third most consumed crop in the world. It is very much beneficial for health because of its high nutrient status. Integrated nutrient management effects on its yield and quality parameters to a great extent. This review paper therefore, present review on various aspects of INM use to improve soil environment and tomato yield and quality parameters.*

Keywords: INM, sustainable agriculture, soil environment, tomato yield, and quality parameters

INTRODUCTION

Can agriculture provide for the food needs of a world population projected to exceed 7.5 billion by the year 2020? Concern is growing that it may not. There are indications that the highly productive fertilizer and seed technologies introduced over the past three decades may be reaching a point of diminishing returns (Bouis and Howarth, 1993). Future food and fiber must be produced on existing agriculture land, with less negative impacts on natural resources and the environment than in the past. The timely supply,

Received 16 December 2008; accepted 29 November 2009.
Address correspondence to M. Qasim Khan, Faculty of Agriculture, Gomal University, Dera Ismail Khan, 2930, Pakistan. E-mail: drqasim02@yahoo.com

efficient use, and careful monitoring of nutrients in integrated crop, forage, and tree production systems offer the potential for significant improvement of efficiency in plant nutrient use. Integrated nutrient management (INM) is an approach that involves the management of both organic and inorganic plant nutrients for optimal production of cultivated crops, forage, and tree species, while conserving the natural resource base essential for long-term sustainability (Smaling, 1993).

Integrated nutrient management can reduce plant requirements for inorganic nitrogen fertilizer, and reduced use of purchased fertilizer nutrients can result in a significant saving of scarce cash resources for small farmers. It also ensures the Conservation and efficient use of native soil nutrients, recycling of organic nutrient flows, Enhancing biological nitrogen fixation and soil biological activity and addition of plant nutrients (Vlaming et al., 1997).

There is increased emphasis on the impact on the environmental quality due to continuous use of chemical fertilizers. The INM system is an alternative and is characterized by reduced input of chemical fertilizers and combined use of chemical fertilizers with organic materials. For sustainable crop production integrated use of inorganic and organic fertilizers has proved to be highly beneficial (Anderson et al., 2002). Moreover, INM reduces erosion, improves water infiltration, soil aeration and plant root growth, Moreover, it minimizes the risk of downstream flooding (Smaling, 1993).

Tomato (*Lycopersicon esculentum*) is a nutritious and popular product all over the world. At present tomatoes ranked third, next to potatoes and sweet potatoes, in term of global vegetable production (FAO, 2002). However average tomato yield in Pakistan is quite low (9.6 t ha^{-1}) as compared to other countries of south and southeast Asia, such as India (17.00 t ha^{-1}), Thailand (23.79 t ha^{-1}) as well as being low compared to the average yield grown in Asia (24.30 t ha^{-1}) and world (26.74 t ha^{-1}) Nutritive fertilizer may be applied in three verities viz. Organic, inorganic and integrated use of organic manure and inorganic fertilizers. The majority of tomato growers do not produce good quality fruit at high yield because of their lack of knowledge regarding improved production technology, including use of proper inorganic and organic fertilizers (FAO, 2003).

Organic manure along with inorganic fertilizers might be helpful to obtain a good economic return as well as provide favorable conditions for high tomato yield with divine quality and nutrient status. (Solaiman and Rabbani, 2006). Therefore, this review paper focuses discussion on the impact of INM of organic and inorganic fertilizer sources on soil environment and tomato quality parameters so that conclusion can be drawn as to how far the use of INM is helpful in sustaining soil quality and tomato's yield and nutrient status.

Downloaded By: [Universidad Publica de Navarra] At: 09:53 16 May 2011

Downloaded By: [Universidad Publica de Navarra] At: 09:53 16 May 2011

Effect on Soil Environment

Effect on Soil Chemical and Physical Properties

Soil chemical properties are evaluated if organic and inorganic fertilizers are used in combination as their combine effect improves soil organic matter, percentage of organic carbon and total nitrogen. Addition of organic fertilizer results in increased total organic carbon (C) (TOC) levels in the soil while chemical fertilizer result in decreased TOC and basic cation contents, and lowering of soil pH. As a result, a positive effect on soil results in modification of soil structure thereby increases the yield in the long term (Reza and Jafar, 2007). Along with the evaluation of soil chemical properties, soil physical properties are also enhanced by the use of INM, as it reduces soil erosion and increases cycling of organic residues. Thus it improves both nutrient and water retention capacity of the soil. This management also improves the soil structure, water infiltration, and soil aeration (Vlaming et al., 1997).

Effect on Soil Biological and Enzyme Activities

The activity of soil organisms is very important for ensuring sufficient nutrient supply to the plant. If microorganisms find suitable conditions for their growth, they can be very efficient in dissolving nutrients and making them available to plants. Moreover, an increase in soil microbial-biomass C and nitrogen (N) is obvious in soils receiving combined application of organic manures and chemical fertilizers compared to soils receiving chemical fertilizers only. Basal and glucose-induced respiration, potentially mineralizable N, and arginine ammonification are higher in soils amended with organic manures with chemical fertilizers, indicating that more active microflora is associated with integrated system using organic manures and chemical fertilizers together which is important for nutrient cycling. The use of organic fertilizer together with chemical fertilizers, compared to the addition of organic fertilizers alone, has an higher positive effect on microbial biomass and hence soil health (Dutta et al., 2003) (Table 1). The INM changes the chemical and biological properties in soils, it improves the soil organic C, total N, phosphorus (P), and potassium (K) status and microbial biomass (C and N), and soil organic matter (OM) content and long-term soil productivity in the tropics where soil OM content is low. Soil biomass is increased by INM as these amendments supply readily decomposable organic matter in addition to increasing root biomass and root exudates due to greater crop growth (Goyal et al., 1999).

As for as the enzyme activities are concerned the urase and alkaline phosphates activities of soil increases significantly with a combination of inorganic fertilizers and organic amendments as enhanced enzyme activities are always related to soil organic matter content (Frankenberger and Dick, 1983) (Table 1).

TABLE 1 Amounts of microbial biomass C and activities of dehydrogenase, unease and alkaline phosphatase in soils as affected by different fertilizer treatments (*TPF* triphenyl)

Treatment	Microbial biomass C (mg kg $^{-1}$ soil)	Biomass C as% of soil C	Dehydrogenase activity (μg TPF g^{-1} soil 24 h^{-1})	Urease activity (μg NH^{+}$_4$ -N g^{-1} soil h^{-1})	Alkaline phosphatase activity (μg PNP g^{-1} soil h^{-1})
N_0, P_0	147	3.3	38	42	416
N_{60}, P_{30}	195	3.78	37	55	423
N_{90}, P_{45}	213	3.7	37	60	425
N_{120}, P_{60}	226	3.9	35	64	433
N_{90}, P_{45} + N_{30} (FYM)	273	4.4	39	65	498
N_{90}, P_{45} + N_{30} (wheat straw)	423	6.5	67	88	541
N_{90}, P_{45} + N_{30} (green manure)	317	5.1	34	68	473
LSD (*P* 0.05)	15	0.3	4	5	18

Source: Goyal et al. (1999).

Downloaded By: [Universidad Publica de Navarra] At: 09:53 16 May 2011

Influence on C:N Ratio

A more fundamental understanding of the importance that plant nutrient status, especially C and N, has on the development of carotenoids can found in ecological theories (e.g., carbon/nitrogen balance and growth/differentiation balance) predicting levels of secondary metabolites based on availability of plant nutrients and conditions that enhance disease resistance. According to these theories, plants will selectively produce compounds for growth or differentiation relative to the abundance of C and N resources (Stamp, 2003). Nitrogen-containing compounds will be favored over C-based secondary compounds when N is readily available and not limiting for growth. Carbon-based compounds, such as lycopene and beta-carotene, will be produced in carbon sufficient conditions when photosynthetic activity is not simultaneously reduced (Stout et al., 1998). Soil organic C and total N are greater in treatments receiving a combination of inorganic fertilizers and organic amendments compared to soils receiving inorganic fertilizers alone (Table 2). The greatest amounts of both organic C and total N are observed in soils receiving wheat straw and least organic C and total were present in unfertilized soils. The C:N ratio of soil decreases with fertilization. The organic amendments show a greater effect in decreasing C: N ratio compared to inorganic fertilizers. Soil organic C and N contents provide a measurement of soil organic matter status. The increase in soil organic matter with the application of inorganic fertilizers is because of greater input of root biomass due to better crop growth (Goyal et al., 1992). If straw amendments are applied it will result in more soil organic matter compared to FYM and *S. bispinosa* green manure. The C: N ratio provides information on the capacity of the soil to store and recycle energy and nutrients. A

TABLE 2 The pH, soil organic C and total N as affected by different fertilizer treatments. N0, N30, N60, N90 and N120 represent 0, 30, 60,90 and 120 kg N ha P1, respectively, from urea. P0, P30, P45 and P60 represent 0, 30, 45 and 60 kg P2O5 ha P1, respectively, from single superphosphate

Treatment	pH	Organic C (%)	Total N(%)	C:N ratio
N_0P_0	7.4	0.45	0.04	11.3
$N_{60}P_{30}$	7.3	0.51	0.05	11.1
$N_{90}P_{45}$	7.3	0.58	0.05	10.9
$N_{120}P_{60}$	7.5	0.58	0.06	9.4
$N_{90}P_{45}$+N_{30} (FYM)[a]	7.3	0.63	0.07	9.1
$N_{90}P_{45}$ + N_{30} (wheat straw)[b]	7.4	0.65	0.08	8.7
$N_{90}P_{45}$+N_{30} (green manure)[c]	7.3	0.62	0.06	9.7
LSD (*P* 0.05)	0.2	0.01	0.004	0.9

[a]FYM = 600 kg C ha^{-1}.
[b]Wheat straw = 3048 kg C ha^{-1}.
[c]*S. bispinosa* green manure = 553 kg C ha^{-1}.
Source: Goyal et al. (1999).

Downloaded By: [Universidad Publica de Navarra] At: 09:53 16 May 2011

decrease in soil C:N ratio with organic amendments indicates the build-up of N pool in the soil (Goyal et al., 1999).

Effect on Yield and Yield Attributes of Tomato

Targeting high yield with a high cropping intensity is the most logical way to raise the total production from the country's limited resources. Since the nutrient turnover in soil plant system is considerably high in intensive farming, neither the chemical fertilizers nor the organic and biological sources alone can achieve production sustainability. Even with balanced use of chemical fertilizers high yield level could not be maintained over the years because of deterioration in soil physical and biological environments due to low organic matter content in soils. In this context and as a further response to economic recession, and also to conserve and improve soil fertility the concept of INM system has been adopted (Quamruzzaman, 2006). It improves stem height, number of leaves, branches and dry matter. Moreover number of flower $plant^{-1}$, number of fruits $plant^{-1}$, percentage of fruit set and average fruit weight) of tomato also increases significantly. (Roy, 1986). At the same time the integrated use of inorganic fertilizer and organic manure results in important yield attributes like fruit setting, plant height, number of primary branches per plant, and total soluble solid contents (Patil et al., 2004) (Tables 3, 4, and 5).

Effect on Nutrient Status of Tomato

Organic fertilization results in low yields with high vitamin C content, whereas mineral fertilization gave higher yields with lower vitamin C content. If organic and mineral fertilizers are used they increase the yield and vitamin C (Dumas et al., 2003). Fruits and vegetables grown with INM treatment

TABLE 3 Fruit setting as affected by organic manure and chemical fertilizer

Treatment	Fruit setting rate (%)
T_1. Control	62.95
T_2. N_{200}+P_{35}+K_{80}+S_{15}	75.50
T_3. Cow dung $_5$ +1/2 of T_2	76.60
T_4. Cow dung $_{10}$+1/3 of T_2	78.88
T_5. Cow dung $_{15}$	75.52

Source: Solaiman and Rabbani (2006).

have higher levels of cancer-fighting antioxidants, higher mineral levels and higher phytonutrients (plant compounds which can be effective against cancer) than conventionally grown foods. (American Chemical Society, 2003). Lycopene has been reported to be a good indicator for fruit maturation. Lycopene contents are highest for INM and lowest for the organic manure only (Lopez et al., 1996). Pimpini et al. (1992) stated that INM results in improved fruit color of processing tomato that is mainly because of lycopene. Organic manure along with sulfur containing fertilizers gave the highest sweetness, typical tomato flavor, and overall acceptance (Heeb et al., 2005).

Effect on Environment

Another aspect of combining organic and mineral fertilizers is the environmentally friendly production factor. Soil fertility and environment are closely interlinked. Depletion of soil fertility means degradation of the environment and likewise, its improvement also leads to the better environment.

TABLE 4 Yield and yield attributes of tomato as affected by organic manure and chemical fertilizer

	Treatment combination							
Tr. No.	Chemical fertilizer kg ha^{-1}	PM t ha^{-1}	CD t ha^{-1}	Plant height (cm)	Fruits/ plant (no.)	Fruit weight/ plant (kg)	Yield (t ha^{-1})	% increase over control
T_1	100% RD	2.5	0	58.8	38.7a	2.79a	75.00a	276
T_2	100% RD of T_1	0	2.5	54.8	35.0abc	2.44bc	66.10bc	232
T_3	100% RD of T_1	0	0	55.9	36.0*a*bc	2.38c	64.80bc	225
T_4	50% RD of T_1	0	0	54.2	30.0bcd	2.27c	48.13d	141
T_5	50% RD of T_1	5	0	55.9	36.0*a*bc	2.58bc	68.14ab	242
T_6	50% RD of T_1	10	0	57.0	36.7ab	2.70ab	70.81ab	255
T_7	50% RD of T_1	0	10	54.6	32.3a–d	2.34c	60.27c	202
T8	0	10	0	50.7	25.7de	1.65d	40.69e	104
T9	0	0	10	49.9	19.7ef	1.21e	28.77f	44
T10	Native nutrient	0	0	48.4	14.7f	0.85f	19.93g	—
	CV (%)			6.7	13.8	7.5	7.3	

Means followed by common letter(s) do not differ significantly at 5 percent level by DMRT.
RD = Recommended dose of chemical fertilizer = $N_{150}P_{45}K_{80}S_{25}Zn_2B_1$ kg ha^{-1}
Source: BRRI (2001).

Downloaded By: [Universidad Publica de Navarra] At: 09:53 16 May 2011

TABLE 5 Effect of FYM and inorganic fertilizer application on performance of tomato

Treatment	Days to flowering	Fruit yield (Mg ha^{-1})	Straw yield (Mg ha^{-1})	% increase yield
Control	55.33	34	8	—
6 Mg/ha FYM	59.33	28	9	12.5
2 Mg/ha FYM	58.33	31	6	25
2 Mg/ha FYM+ 61 kg N+ 31 kg P/ha	49.00	47	12	50
92 kg N/ha+ 46 kg P/ ha + 2 Mg/ha FYM	51.67	38	11	37.5
LSD (0.05)	4.88	12	3	—
CV (%)	4.88	17.15	18.16	—

Source: Teklu et al. (2004).

Downloaded By: [Universidad Publica de Navarra] At: 09:53 16 May 2011

The depletion of nutrients (fertility erosion) is wide spread on the earth as well as in developing countries. The major forms and causes of nutrient depletion include excessive crop nutrient uptake and removal, leaching, gaseous loss, irascible fixation in the soil and immobilization in the trunks and branches of the tree crops (BRRI, 2001). Moreover, If an unbalanced organic fertilizer is supplied at levels that satisfy the demands of the limiting nutrient (here S or P), a large surplus of other nutrients, especially nitrogen, would be supplied, with a probable risk for leaching (nitrate, NO_3^-) or volatile losses (ammonia, NH_3), and thereby negative effects on the environment (Heeb et al., 2005). INM practices reduces the emission of green house gases (nitrous and nitric oxides) excessive applications of nitrogen fertilizer results in increased leaching of nitrates into ground water, increasing health risks to new borne infant flows cycled through the return of organic residues as compost, manure and/or mulch have significant implications for conserving soil fauna biodiversity (Smaling, 1993)

Economic Performance

The highest gross return (benefit cost ratio) can be obtained if integrated dose of inorganic fertilizer is applied with organic manure (Table 6).

TABLE 6 Effect of integrated use of organic and inorganic fertilizers on benefit to cost ratio

Treatment	Benefit to cost ratio
T_1. Control	3.21
T_2. N_{200}+P_{35}+K_{80}+S_{15}	4.36
T_3. Cow dung $_5$ +1/2 of T_2	4.38
T_4. Cow dung $_{10}$+1/3 of T_2	4.17
T_5. Cow dung $_{15}$	3.52

Source: Solaiman and Rabbani (2006).

Precautions while Applying INM

Concern has also grown in recent years that the use of fertilizers, particularly inorganic fertilizers, can lead to serious environmental consequences. Environmental contamination of this type, however, is largely a problem in the developed world and a few regions of the developing world. As fertilizers make up a small share of the total production costs in many developed countries, farmers often apply fertilizer in excess of recommended levels in order to ensure high yields. Over application of inorganic and organic fertilizers is estimated to have boosted nutrient capacity in the soil by about 2,000 kilograms of nitrogen, 700 kilograms of phosphorus, and 1,000 kilograms of potassium per hectare of arable land in Europe and North America during the past 30 years (World Bank, 1996). Such oversupply of nutrients can lead to environmental contamination, which often has negative consequences for humans and animals. Over application of nitrogen, for example, allows the nutrient to be carried away in groundwater and to contaminate surface water and underground aquifers. Ingestion of nitrate can be toxic to humans and animals when it transformed within the body into nitrite, which affects the oxygen-carrying ability of red blood cells. Evidence also suggests that nitrite and the carcinogenic compounds it can create may also lead to goiter, birth defects, heart disease, and stomach, liver, and esophagus cancers (Conway and Pretty, 1991).

Downloaded By: [Universidad Publica de Navarra] At: 09:53 16 May 2011

Constraints in Dissemination and Implementation of INM

According to a survey, farmers obtained more agricultural knowledge and experience from their neighbors than from the agricultural technology extension technicians. The low efficiency of the extension services also contributed substantially to the low contribution rate of science and technology to agricultural development (Fan and Youhuan, 1999). In recent years, despite rapid development of non-governmental agrotechnological service, dissemination of agricultural technology is still very limited. For example, even with the various agro-chemical services set up by numerous fertilizer enterprises, there has still low technology transfer since their services have focused mainly on fertilizer sales rather than integrated nutrient management techniques. Limitation of small holdings The small-holding farms restricted nutrient management technical extension to a certain extent because the ratio of products for commercial goal is very low ascribe to its small area (He, 2000). On the other hand, small number of staff engaged in soil and fertilizer management in the extension system could not meet the technological demands of farmers. Furthermore, the agro-technological extension technicians generally allocate less than 30 percent of their working time to visiting farmers in villages (Hu and Jikun, 2001). It was therefore difficult for most farmers to gain access to agricultural technicians and technology transfer. Low levels of education and insufficient trainings to improve agricultural knowledge of farmers in developing countries is another constraint for extension of nutrient management technology. Though about 70–80 percent of farmers know that fertilizer application rates should accord with soil fertility and target yield levels, most of them did not know how to determine the fertilizer rate and application time satisfactorily. Improvement of education (formal or informal) and updated technology training to farmers will make an important contribution to improve the provision of agricultural technical extension programmers (He, 2000).

CONCLUSION

On the basis of above review on the use of integrated nutrition management (INM) of organic and inorganic fertilizers in agriculture it can be concluded that it is extremely important combination for sustainable agriculture. It improves the soil organic matter, adds soil macro- and micronutrients, improves soil physical and chemical properties, rejuvenate soil health, and stimulate soil biological and enzyme activities. It has very valuable effect on tomato yield and quality parameters, gives maximum economic benefit and most imperatively, it is environmentally friendly. But if doses of organic and inorganic fertilizers are applied more than the recommended doses according to particular soil type it may affect adversely on the soil and crop. At the same time it is concluded that nitrate fertilizers are better than ammonium fertilizers and poultry manure, FYM or wheat straw are better than any other manure when are combined with inorganic fertilizers. Moreover, governments should take practical steps to promote the implication of INM to enhance the yield of high quality products.

Downloaded By: [Universidad Publica de Navarra] At: 09:53 16 May 2011

REFERENCES

American Chemical Society. 2003. organically grown foods higher in cancer-fighting chemicals than conventionally grown foods. Available at: http://www.sciencedaily.com/releases/2003/03/030304073059.htm Accessed 15 October 15, 2010.

Anderson, J., M. Blackie, M. Eilitta, E. Fernandes, N. Sanginga, E. Smaling, and D. Spencer. 2002. A consultative review of the rockefeller foundation's activities to improve and sustain soil fertility in East and Southern Africa. New York: The Rockefeller Foundation.

Bouis, H. E. and E. Howarth. 1993. Measuring the sources of growth in rice yields: Are growth rates declining in Asia? *Food Research Institute Studies* 22: 305–330.

BRRI. 2001. Bangladesh Agricultural Research Institute Annual Report. Gazipur, Bangladesh: BARI.

Conway, G. R., and J. N. Pretty. 1991. *Unwelcome Harvest: Agriculture and Pollution*. London: Earthscan Publications Ltd.

Dumas, Y., M. Dadomo, G. Di Lucca, and P. Grolier. 2003. Effects of environmental factors and agricultural techniques on antioxidant content of tomatoes. *Journal of the Science of Food and Agriculture* 83: 369–382.

Dutta, S., R. Pal, A. Chakeraborty, and K. Chakrabarti. 2003. Influence of integrated plant nutrient supply system on soil quality restoration in a red and laterite soil. *Archives of Agronomy and Soil Science* 49: 631–637.

Fan, Q., and G. Youhuan. 1999. The rank of limitation factors for agro-technology extension in China. *Agriculture Technological Economics*, (23): 12–15.

FAO. 2002. *FAO Production Year Book 1996*. Rome: FAO.

FAO. 2003. *Fao Bulletin of Statistics*, Vol. 3, No. 2. (2002). Rome: FAO.

Frankenberger, J., and W. Dick. 1983. Relationships between enzyme activities and microbial growth and activity indices in soil. *Soil Science Society of America Journal* 47: 945–951.

Goyal, S., K. Chander, M. C. Mundra, and K. K. Kapoor. 1999. Influence of inorganic fertilizers and organic amendments on soil organic matter and soil microbial properties under tropical conditions. *Journal of Biology and Fertility* 29: 196–200.

Goyal, S., M. M. Mishra, I. S. Hooda, and R. Singh. 1992. Organic matter microbial biomass relationships in field experiments under tropical conditions: Effects of inorganic fertilization and organic amendments. *Soil Biology and Biochemistry* 24: 1081–1084.

He, W. 2000. Difficulties and countermeasures in agro-technology extension of China. *Journal of Beijing Agricultural Administration College* 14(4): 10–11.

Heeb, A., B. Lundegardh, T. Ericsson, and G. P. Savage. 2005. Effects of nitrate, ammonium and organic nitrogen based fertilizers on growth and yield of Tomatoes. *Journal of Plant Nutrition and Soil Science* 168: 123–129.

Hu, R., and H. Jikun. 2001. Current situation of investment of agro-technology extension and its effect in China. *Strategy and Management* 8: 25–31.

Lopez, J., N. Tremblay, W. Voogt, S. Dubé, and A. Gosselin. 1996. Effects of varying sulphate concentrations on growth, physiology and yield of the greenhouse tomato. *Scientia Horticulturae* 67: 207–217.

Patil, M. B., R. G. Mohammed, and P. M. Ghadge. 2004. Effect of organic and inorganic fertilizers on growth, yield and quality of tomato. *Journal of Maharashtra Agricultural Universities* 29: 124–127.

Pimpini, F., L. Giardini, M. Borin, G. Gianquin.1992. Effects of poultry manure and mineral fertilizers on the quality of crops. *Journal of Agricultural Science 1992*, 118(2): 215–221

Quamruzzaman, M. 2006. Improving plant nutrient management for better farmer livelihoods, food. Available at: http://www.fao.org/docrep/010/ag120e/AG120E08.htm Accessed 15 October 2010.

Reza, M. T., and K. Jafar. 2007. Influence of organic and chemical fertilizers on growth and yield of tomato (*Lycopersicon esculentum* L.) and soil chemical properties. Annual Report. Tehran, Iran: Shahid Beheshti University.

Roy, R. N. 1986. FAO Fertilizer Programme with Special Reference to Integrated Plant Nutrition System. Fertilizer in Agricultural Development. New Delhi, India: Krishak Bharati Cooperative Limited.

Smaling, E. M. A. 1993. Soil nutrient in Sub-Saharan Africa. In: *The Role of Plant Nutrients for Sustainable Food Crop Production in Sub-Saharan Africa*, eds. H. van Reuler and W. H. Prins, pp. 53– 67. Leidschendam, the Netherlands: Vereniging van Kunstmest Producenten.

Solaiman, A. R. M., and M. G. Rabbani. 2006. Effects of N P K S and cow dung on growth and yield of tomato. *Bulletin of the Institute of Tropical Agriculture, Kyushu University* 29:31–37.

Stamp, N. 2003. Out of the quagmire of plant defense hypotheses. *Quarterly Review of Biology* 78: 23–55.

Stout, M. J., R. A. Brovont, and S. S. Duffey. 1998. Effect of nitrogen availability on expression of constitutive and inducible chemical defenses in tomato. *Journal of Chemical Ecology* 24: 945–963.

Vlaming, J., J. N. Gitari, and M. S. van Wijk. 1997. Farmers and researchers on their way to integrated nutrient management. *ILEIA Newsletter* 13(3): 6.

World Bank. 1996. Sub-Saharan Africa, from crisis to sustainable growth. New York: World Bank.

Downloaded By: [Universidad Publica de Navarra] At: 09:53 16 May 2011