International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(6): 510-517

Received: 18-09-2018
Accepted: 20-10-2018

Tariq A Bhat
Division of Vegetable Science, Faculty of Horticulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar, Jammu and Kashmir, India

Asif M Rather
Division of Vegetable Science, Faculty of Horticulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar, Jammu and Kashmir, India

Muzamil A Hajam
Division of Vegetable Science, Faculty of Horticulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar, Jammu and Kashmir, India

Saima Paul
Home Science SMS, KVK Kulgam-SKUAST-K, Srinagar, Jammu and Kashmir, India

Correspondence
Tariq A Bhat
Division of Vegetable Science, Faculty of Horticulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar, Jammu and Kashmir, India

Integrated nutrient management and its components in vegetable production

Tariq A Bhat, Asif M Rather, Muzamil A Hajam and Saima Paul

Abstract
INM system is to handle and sustain the agricultural output and improve the farmer's productivity through the cautious and efficient use of chemical fertilizers, organic manures, green manures, and compost including vermicompost, crop residues and bio-fertilizers. However, this does not mean adding everything everywhere; rather, a well-considered practical and proficient blend of varied nutrient sources is required which can produce desired yields and maintain soil health on long-term basis. INM system helps to restore and sustain crop productivity, and also assists in checking the emerging micronutrient deficiencies. Further, it brings economy and efficiency in the use of fertilizers INM system is to manage and sustain the agricultural productivity and improve the farmer's profitability through the judicious and efficient use of chemical fertilizers, organic manures, green manures, and compost including vermicompost, crop residues and bio-fertilizers. However, this does not mean adding everything everywhere; rather, a well-considered practical and efficient blend of diverse nutrient sources is required which can produce desired yields and maintain soil health on long-term basis. INM system helps to restore and sustain crop productivity, and also assists in inspection the emerging micronutrient deficiencies. Further, it brings economy and efficiency in the use of fertilizers.

Keywords: INM, economy and yield

Introduction
With the increase in population, the demand for vegetables rapidly increased. Through India has emerged as second largest vegetable producing country in the world, but the present level of production is not able to make pace with the increasing population. The present situation though a bit comfortable, but to meet the future demand, we would need better planning and resource management. It is anticipated that in the year 2025, our vegetable requirement/demand will be 225 million tons against the limitations of expansion of the cultivable land area. The only alternative to achieve this goal is to raise the vegetable production level, through use of high yielding varieties/hybrid, modern production technology. Integrated nutrient management is one of the most important component of modern production technology to sustain the vegetable production and soil fertility in the future. Plant nutrients can be supplied from different sources i.e., organic manures, composts/vermicompost, crop residues, green manures, biofertilizers and chemical fertilizers. For better utilization of resources integrated nutrient management is the best approach to utilize all possible sources of plant nutrients on the basis of economic considerations and the balance required by the crop is supplemented with chemical fertilizers. The combined application of organic and inorganic sources of plant nutrients not only enhance the vegetable production, profitability but at the same time helps in maintaining the soil fertility.
Keeping in view the present fertility status of vegetable growing areas, decline in the yield and quality of vegetables, concerns on nutritional and health security, environmental hazards, it is desirable for making massive efforts to adopt organics as a vital source of plant nutrients along with inorganic ones as their sole applications are in no way, a solution to sustain soil fertility and crop productivity.

Principles of integrated nutrient management
INM is a holistic approach of plant nutrient management by considering the totality of the farm resources that can be used as plant nutrient and is based on three principles:
1. Maximize the use of organic material
2. Ensure access to inorganic fertilizers

3. Improve the efficiency of their use and minimize the loss of plant nutrients.

Objectives of INM

1. It should increase the availability of nutrients from all sources in the soil during cropping season.
2. It should match the demand of nutrients by the crop.
3. It should optimize the functioning of the soil biosphere with respect ot specified functions such as decomposition of organic matter (mineralization), the control of pathogenic organisms by their natural enemies, the biological formation of soil structure (aggregates, biopores) the decomposition of phytotoxic compounds etc.
4. It should minimize the losses of nutrients to the environment, through ammonia volatalization, denitrification in case of nitrogen, surface runoff and leaching NO_3 and PO_4 beyond the rooting zone and prevent eutrophication of the water bodies and ensure no build up of the toxic metals in the soil.

In general, the major objective of INM is to integrate the use of all natural and manmade sources of plant nutrients, so that crop productivity increases in an efficient and eco-friendly manner, without sacrificing soil productivity of future generations.

Components of INM

Organics

Organic manures

Organic manures is one of the major and commonly used organic nutrient component in INM. Organic manures include farm yard manure, compost, vermicompost, poultry manure, sheep manure, night soil, oil cakes and excrete of other animals. The annual production of organic manures in India is estimated to provide 17.82 million tons of NPK which is 8.0 million tons less than the required for producing 2.30 million tons of food. The nutrient value of organic manures is not comparable to inorganic fertilizers. However, poultry manure/ vermicompost/oil cakes are comparatively richer sources of nutrients and all of them play a vital role in maintaining soil fertility though their effects on physico-chemical properties of soil (Tandon, 1992) [11]. Importance of organic manures in vegetable production is an established fact. Organic manures release nutrients decomposition. Organic manures contain small percentage of nutrients and are applied in large quantities (Table-1).

Table 1: Nutrient status of some organic manures

Category	Source	Nutrient content (%)		
		N	**P_2O_5**	**K_2O**
Animal wastes	Cattle dung Cattle urine	0.3-0.4 0.80	0.10-0.15 0.01-0.12	0.15-0.20 0.50-0.70
Sheep and goat dung (mixed)		0.65	0.05	0.03
Night soil		1.2-1.5	0.8	0.5
Leather waste		7.0	0.1	0.3
Hair and wool waste		12.3	0.1	0.3
FYM/composts	Farm yard manure	0.5-1.0	0.15-0.20	0.4-0.6
	Poulry manure	2.87	2.90	2.35
	Town compost	1.5-2.0	1.0	1.5
	Rural compost	0.1-1.0	0.2	0.5
	Water hyacinth compost	2.0	1.0	2.3
Oil cakes	Castor	5.5-5.8	1.8	1.0
	Cotton seed	3.9	1.8	1.6
	Pongamia pinnata	3.9-4.0	0.9-1.0	1.3
	Neem	5.2	1.0	1.4
	Niger	4.8	1.8	1.3
	Bassia latifolia	2.5-2.6	0.8	1.8
	Rape seed	5.1	1.8	1.0
	Linseed	5.5	1.4	1.2
	Sunflower	4.8	1.4	1.2
Animal meals	Blood	10-12	1.2	1.0
	Raw bone	3-4	20-25	---
	Steamed bone	1-2	25-30	---
	Fish meal	4-10	3-9	1.8

Source: Gaur (1992)

Advantages

1. They improve soil physical properties.
2. Supply macro, secondary and micronutrient.
3. Increase nutrient availability.
4. When applied with mineral fertilizers, it improves the efficiency of latter due to their favorable effects on soil properties.
5. Add nutrients to the soil and reduce dependence on fertilizer (Sharma, 2008).
6. Organic manures increase P availability as they have very high cation exchange capacity (Gaur, 1990) [3].
7. Organic manures exhibits residual effect, as they are not fully utilized by the crop in the 1st year of application. Nitrogen released by them is very slow (less than 30%) and the balance becomes available for the subsequent crop.
8. Improves soil tilth and water holding capacity.
9. All this underlines the need to apply these manures along with chemical fertilizers in INM system. The influence of INM system on growth, yield and quality of vegetable crops is presented in Table-2 (a&b).

Table 2(a): Effect of Chemical fertilizers, Organics and their Integration on the Yield/Quality of Vegetable crops

Crop	Yield (qha^{-1})			Source
	Chemical fertilizers	Organics	Integration of chemical fertilizers with organics	
Brinjal	378.00	351.50	454.66	Jose *et al*, (1988)
Okra	108.37	101.93	164.53	Abusaleha & Shamugavelu (1988)
Chilli	61.12	63.93	70.75	Malewar *et al*, (1998)
Tomato	276.20	196.30	277.10	Bhardwaj *et al*, (2000)
Brinjal	96.40	95.70	96.20	Rao *et al*, (2001)
Capsicum	248.66	193.95	296.63	Magray *et al*, (2002)
Tomato	385.77	291.69	510.84	Rafi *et al*, (2002)
Cabbage	332.96	319.29	329.95	Chattoo *et al*, (2003) [2]
Onion	171.60	78.50	187.70	Sharma *et al*, (2003) [9]
Carrot	74.61	73.28	76.36	Singh *et al*, (2003)
Pea	58.00	39.00	103.00	Ndatt *et al*, (2003)
Okra	63.74	56.35	67.21	Ray *et al*., (2005)
Cabbage	372.40	357.00	370.00	Chattoo *et al*, (2006)
Okra	259.24	211.01	272.71	Chattoo (2006)
Capsicum	430.48	-	686.39	Malik (2008)
Okra (seed yield)	23.26	22.72	26.62	Chattoo *et al*, (2009)
Tomato Fruit yield Seed yield	302.58 1.15	259.25 1.02	318.79 1.14	Anonymous (2009) Anonymous (2009)
Beans	133.77	119.63	136.87	Anonymous (2009)
Onion	331.94	273.33	336.71	Chattoo *et al*, (2010)
Potato	272.59	273.79	-	Mubarak (2013)
Kale	520.37	466.26	680.44	Dass, (2014)
Brinjal	340.76	316.51	395.42	Shahnaz (2015)
Chinese Cabbage	239.30	348.81	286.40	Arif Ibrahim (2016)

Table 2(b): Effect of organic manures on quality of vegetables

Organic and inorganic sources of plant nutrients enhanced fruit quality in Okra	Abusaleha & Shamugavelu, 1988
Poultry manure application enhanced dry matter content and uptake of nutrients in Brinjal cv. MDU-1	Jose *et al*., 1988
Cattle, sheep and poultry manures proved effective in controlling the root knot nematode in Okra	Montasser, 1990
Application of linseed cake + fertilizer recorded lowest galls/plant in tomato	Shah *et al*., 1992
Application of FYM, PM, SM and cakes significantly decreased nematode development in Okra	Khan, 1994
Organic manures depicted lower nitrate levels in carrot	Rembialkowska & Fiedorow, 1998
FYM effectively controlled *Fusarium* yellow disease in bean	Mutitu *et al*., 1998
FYM + NPK combination increased microbial population	Maheswarappa *et al*., 1999
Organically grown tomato has lower dietary fiber content, higher sugar and malic acid content	Lucarini *et al*., 1999
Organic manures depicted higher protein, vit. C content, lower nitrate levels and better shelf life in vegetables	Singh *et al*., 2000
Organically grown tomato plants were resistant to P infestans	Wang *et al*., 2000
Organic manures depicted higher dry mater and ascorbic acid content and lower calcium content in cabbage	Fiedorow, Magroy, 2002
Organic manures enhanced P and Ca content in tomato fruits	Colla *et al*., 2002
Organic and inorganic sources exhibited sustainability in quality of cabbage	Chattoo *et al*., 2003 [2]
Combined application of FYM + 50 RFD improved qualiy in tomato	Narayan *et al*., 2004
Organics and their integration with in-organics improved fruit and seed yield in Okra	Chattoo (2006)
Sole application of organics (Biofertilizers) and their integration with chemical fertilizers enhanced the Rhizoshere microbial population in Okra-Pea cropping sequence	Chattoo (2006)
Congugation of organic manures and chemical fertilizers exhibited a positive influence on quality parameters of Capsicum	Malik (2008)
Integration of organics in equal proportion registered an improvement in quality attributes of Brinjal	Shahnaz (2015)
Combined application of poultry manure and chemical fertilizer in 50 : 50 ratio exhibited better quality traits in Brinjal	Shahnaz (2015)

Compost

Compost is an amorphous brown to dark humified material produced as a result of microbial decomposition of organic wastes collected from urban and rural wastes. In addition to microbial decomposition, machines are also used to produce compost, commonly known as mechanical compost. Soil invertebrates (earth worms) are also used effectively for recycling of non-toxic/degradable organic wastes to the soil. Culturing of earth worms is referred as vermiculture and the recycled produce, which is granular is referred as vermicompost. Compost are rich sources of essential plant nutrients. Besides, nutritional richness, composts are known to improve the physical, chemical and biological properties of the soil. Composts are also helpful in reducing the outlay on fertilizers. The beneficial effects of compost on yield and quality of vegetables has been reported by a number of research workers (Table-3). Composts are also known to provide additional benefits like suppression of soil borne plant pathogens and biological weed control.

Table 3: Influences of compost, vermicompost either alone or in combination with inorganic fertilizers on vegetable crop improvement

Compost from kitchen wastes, yard wastes & FYM	Improved yield, quality and storage performance of cabbage, carrot, tomato and potato resulted in superior sensory quality of tomato	Vogtmann *et al*., 1993
Vermicompost	Suppressed the development of diseases in tomatoes and cabbage, thus can be used as a bio-pesticide	Szczech and Brezeski., 1994
Vermicompost	Reduced nitrate, cadmium and lead levels in cucumber and carrot	Kolodziej and Kostecka., 1994
Chicken manure compost	Equally efficient as that of Nitrogen fertilizer produced higher yield in sweet corn and cabbage	Nishiwaki & None 1996
Straw and cattle manure compost	Increased total carbon content of soil	---do---
Cattle manure compost	Reduced nutrient leaching	---do---
Coffee pulp compost	Reduced the reproduction of *M. javarica* in tomato	Zambolim., 1996
Vermicompost + DOS + 75% NPK dose (digested organic supplement)	Recorded highest TSS and ascorbic acid content in cabbage	Mahendran and Kumar., 1997
Vermicompost	Increased the growth and yield of onion in mine soil	Thanunathan *et al*., 1998
Vermicompost	Reduced the number of galls and egg masses of *Meliodogyne javanica* in lettuce	Ribeiro *et al*., 1998
Compost from municipal solid waste	Increased water and fertilizer conservation in sandy soil	Qzores Hampton *et al*., 1998
Sea wood compost	Increased growth rate, protein lipids and moisture content of vegetable	Zahid., 1999
Vermicompost 12 t ha-1 + 100% RFD	Recorded highest yield of 5663 kg ha-1 in Okra Reduced significantly the cost of production	Ushakumari *et al*., 1999 ---do---
Vermicompost	Was found effective to inhibit infections by *Oxysporum f.* sp. *Lycopersici* (causing Fusarium wilt) in tomato plants	Szczech., 1999
Vermosole (Vermicompost extract)	Increase tomato yield by 7.3%, decreased nitrate content of fruits by 15%	Lozek and Gracova., 1999
MSWC + N fertilizer @ 134 t ha^{-1}	Increased yields of tomato by 22% peppers by 17% over non-compost plots	Clark *et al*., 2000
Compost application in acid soil	Increased yields of spinach and lettuce over mineral fertilizer or control	Guodufa., 2000
Compost pure or N enriched compost MSWC (Municipal solid waste compost)	Enhanced soil organic mater, total N& K. Reduced heavy metal content in leaves	Dugoni & Berolasi., 2000
Vermicompost processed from pig manure and food	Suitable potting medium for Soil less culture	Atiyeh *et al*., 2000
Vermicompost	Enhanced growth of tomato, pepper & lettuce in soil less culture	Atiyeh *et al*., 2000
Compost from cucumber plant wastes	Increased the cucumber yield by 15% over control	Abon Hadid *et al*., 2001
Compost from chicken manure	Increased the cucumber yield by 34% over control	---do---
Vermicompost + fertilizer	Recorded larger number of fruits higher level of vit C and sugar in tomato cv. Sunny	Premuzic *et al*., 2001
Vermicompost + fertilizer	Depicted significant effect on root shoot growth, fruit weight and number of tomatoes	Samawat *et al*., 2001
Vermicompost (sole)	Was 3, 4, 5 and nine times more than control	---do---
Compost + organic manures 22 t ha^{-1} + 45 t ha^{-1}	Increased available and dissolved organic carbon to un-amended soils	Ercih *et al*., 2002
Compost + organic manures 22 t ha^{-1} + 45 t ha^{-1}	Increased available and dissolved organic carbon to un-amended soils	Ercih *et al*., 2002
Vermicompost + inorganic fertilizer (50% PK) (50% N + K)	Recorded a tuber yield of 308.21 q ha-1 as compared to RFD 353.31 q ha-1 in potato	Upadhayay *et al*., 2003
Vermicompost	Sole application of Vermicompost registered higher fruit yield in Okra as compared to the yield recorded with sole applications of Farm Yard Manure, Sheep manure and bio-fertilizers	Chattoo (2006)
Vermicompost + Chemical fertilizer (50 : 50)	Recorded a fruit yield of 257.76 q/ha which was statistically at par with the yield 259.08 q/ha recorded with RFD, besides recording an improvement in quality attributes of Okra	Chattoo (2006)
Vermicompost+ RFD in equal proportion %0 : 50	Recorded a fruit yield of 369.98 q/ha. Which was 7.89 and 25.08 % more than the yield recorded with RFD and sole application of Vermicompost respectively, besides recorded an improvement in quality attributes	Shahnaz (2015)
Vermicompost + Consortium of bio-fertilizers (Azotobactor,+ PSB+ KSB)	Recorded a fruit yield of 305.9 q/ha. In Chinese cabbage and was 21.77 % more than the yield recorded with RFD	Arif Ibrahim (2016)

Biofertilizers

Are cost effective, eco-friendly and renewable source of plant nutrient to supplements fertilizers for sustainable vegetable production. Hence becomes an integral part of INM. Biofertilizers are the products containing living cell organisms capable of fixing atmospheric nitrogen, solublizing and mobalizing phosphorus in soil, produce growth, promoting and antifungal substances. Biofertilizers include *Rhizobium* (Symbiotic nitrogen fixer), *Azotobactor* and *Azospirriliu*m (Non symbiotic nitrogen fixer) *Pseudomonas, Phosphobacteria, Flavobacterium* (Phosphorous Solublizers) *Vesicular arbuscular mycorhizae* (Phosphorous mobalizers) etc. These biofertilizers are used as seed, seedling and soil inoculant. Biofertilizer application in vegetable production has attained significant importance, as they were found to improve soil fertility, sustain yield and quality of vegetables and reduce pollution (Chattoo *et al*., 2003; Rather *et al*., 2003) [2, 7]. Biofertilizer such *Azotobactor, Azospirrilium,* Phosphobacteria and VAM have been found to economize the N and P fertilizer upto the tone of 25-50% and increase yield by 1-25% (Table-4). Biofertilizer application has brought social, economic and environmental benefits. Application of half RFD + biofertilizers could produce more or less the same economic yields but helps in saving of 25-50% dose of applied N&P.

Table 4(a): Response of vegetable crops to *Rhizobium*, *Azospirillum*, *Azotobacter*, PSM and VAM inoculation

Biofertilizer	Crop	Increase in yield (%)	Nitrogen economy (%)	Source
Rhizobium	Cowpea	4.09	-	Mishra and Solanki (1996)
	Pea	13.38	-	
	Pea	5.10	-	
Azotobacter	Tomato	13.60	50	Kumahaswamy (1990)
	Garlic	14.80	25	Wange (1995)
	Knol khol	9.60	25	Chattoo *et al.* (1997)
	Brinjal	3.5	25	Kamali *et al.* (2002)
	Cabbage	8.60	25	Bhat (2003) M.Sc. thesis, SKUAST (K)
	Garlic	14.23	25	Anonymous (2003)
	Kale	14.34	25	Dass (2014)
Azospirillum	Onion	6.20	25	Gurubatham *et al.* (1989)
	Okra	9.00	25	Subbiah (1991)
	Cabbage	7.00	25	Jeeva Jothi *et al.* (1993)
	Chilli	26.70	25	Paramaguru and Natrajan (1993)
	Chilli	15.10	25	Deva *et al.* (1996)
	Knol khol	14.90	25	Chattoo *et al.* (1997)
	Cabbage	11.87	25	Verma *et al.* (1997)
	Onion	7.74	25	Rather (1997) M. Sc. Thesis, SKUAST-K
	Onion	9.60	25	Thiiackavathy and Ramaswamy (1999)
	Brinjal	3.2	25	Kamali *et al.* (2002)
	Capsicum	9.98	25	Anonymous (2002)
	Onion	21.68	25	Anonymous (2002)
	Capsicum	2.67	25	Chattoo *et al.* (2003) [2]
	Garlic	6.42	25	Anonymous (2003)
	Onion	10.94	25	Chattoo *et al.* (2005)
	Cabbage	9.53	20	Bhat *et al.* (2007)
	Garlic	19.29	25	Chattoo *et al.* (2007)
	Kale	24.44	25	Dass (2014)
Azospirillum+ *Azotobacter*	Kale	37.18	25	Dass (2014)
Azospirillum+PSB	Okra	34.76	-	Chattoo (2006)

Table 4(b): Response of vegetable crops to PSM and VAM inoculation

Biofertilizer	Crop	Increase in yield (%)	Phosphorous economy (%)	Source
PSM and VAM	Tomato	14.20	--	Mohandas (1987)
	Onion	4.70	25	Gurubatham *et al.* (1989)
	Chilli	14.20	--	Biswas *et al.* (1994)
	Potato	20.00	--	Biswas *et al.* (1994)
	Pumpkin	51.00	25	Karauthamani *et al.* (1995)
	Onion	Increase shoot dry weight	25	Kumar and Mangal (1997)
	Onion	9.6	25	Thiikavathy and Ramaswamy (1999)
	Garlic	14.23	25	Anonymous (2003)
	Garlic	19.29	25	Chattoo *et al.* (2007)
	VAM	--	--	--

Green manuring

Crops grown for restoring or increasing the organic matter content in the soil are refered as green manure crops and this cropping system is called as green manuring. Crops here are grown either insitu or brought from outside and upon decomposition, besides releasing nutrients, they add organic matter, produce enzymes, vitamins and antibiotics.

Table 5: Nutrient content of green manuring crops and green leaf manure

Crop/ Plant	Scientific Name	Nutrient content (%) on dry basis		
		N	P_2O_5	K_2O
Green manuring crops				
Sunhemp	*Crotalaria juncea*	2.30	0.50	1.80
Dhaincha	*Sesbania aculeate*	3.50	0.60	1.20
Sesbania	*Sesbanis speciosa*	2.71	0.53	2.21
Wild indigo	*Tephrosia purpurea*	2.40	0.30	0.80
Green leaf manure				
Glyricidia	*Glyricidia sepium*	2.76	0.28	4.60
Pongamea	*Pongamea glabra*	3.31	0.44	1.39
Neem	*Azadirachta indica*	2.03	0.28	0.35
Gulmohar	*Delonix regia*	2.76	0.46	0.50
Peltoforum	*Peltoforum ferrugenum*	2.63	0.37	0.50

Green manuring is known to increase the crop yield by 15-20% besides improving the quality. Sharma and Sharma (1998) reported 4.5 and 4.7 t ha^{-1} increases in tuber yield due to green manuring by dhaincha and sunhemp respectively. While in presence of fertilizer, these two green manure crops resulted in a nitrogen economy of 48 and 44 kg ha^{-1} respectively. Beneficial effect of green manuring in vegetable crops has also been reported by Upadhayay and Sharma, 2000 [2].

Crop rotation

Crop rotation is beneficial in sustaining both yield and quality of vegetables, as it has a potential to overcome all those factors which are responsible for decline in yield like loss of soil fertility, unbalanced nutrient uptake & presence of pest and weeds, legumes in rotation have been found to increase the yield by 25-30%, besides fixing atmospheric nitrogen to the extent of 30-40 kg ha^{-1} in tropical and sub tropical regions. Singh *et al* (1991) [10] reported that legumes in rotation can fix nitrogen from 100-200 kg ha^{-1} within 55 days. Rhizobial inoculation can improve the potential of legumes. Thus crop rotation can be an effective tool in integrated nutrient management for realizing sustainable yields.

Crop residues

Crop residues are non-economical plant parts that are usually left in the field after harvest, left in packing sheds or processing units and serve as a potential source of nutrients, besides promoting and improving soil and water conservation, soil fertility and crop productivity. The potential of crop residues available for recycling in the country has been estimated to be 185263 thousand tones with a nutrition potential of 3320 thousands tones

Table 6: Estimates of the available and realizable plant potential from the residues of principal crops in India

Crop	Residue yield (000' tones)	Nutrient content (%)			Nutrient potential (000' tones)
		N	P	K	
Rice	80744	0.61	0.09	1.15	1493.8
Wheat	44987	0.48	0.07	0.98	688.3
Sorghum	11563	0.52	0.10	0.21	216.2
Maize	6219	0.58	0.09	1.25	119.4
Pearlmillet	8283	0.45	0.07	0.95	121.6
Barley	3180	0.52	0.08	1.25	88.8
Sugarcane	15645	0.45	0.06	1.20	270.7
Potato	5062	0.52	0.09	0.85	73.9
Groundnut	9580	1.65	0.012	1.23	277.3
Total	185263				3320.0

Source: Bharadwaj and Guar (1985)

Combined application of crop residues and chemical fertilizers is a better option for obtaining sustainable vegetable yields, besides improving the soil health. Upadhayay and Sharma (2000) [12] advocated the application of crop residues at the rate of 15 t ha^{-1} for harvesting sustainable yields in cowpea and potato.

Sewage and Sludge

Sewage has been used in agriculture from start of human civilization. Application of sewage in agriculture offers a promising alternative, as sewage is rich in organic matter and nutrients and can be a substitute for irrigation water. The potential benefits of this practice include reduced cost of treatment and energy inputs, reduction/elimination of problems related to sludge handling storage and disposal as well as an increase in the amount of organic matter in the soil. Nutrient supplying potential of sewage is directly related to its composition. In general the sewage contain more than 90% water. The solid portion contains 40-50% orgnaics, 30-40% inert material, 10-15% bio-resistant organics and 5-8% miscellaneous substance on oven dry basis. It contains good amount of NPK and micronutrients like Fe, Zu, Cu, and Mn. However, sewage also contains heavy metals like Pb, Cd, Cr, Co and Ni. These heavy metals pose serious problems regarding metal pollution, eutrophication and ground water contamination by nitrate and health risks from pathogens, are of great concern. Sewage has a positive effect on vegetable production and it not only increases the yield but has also resulted in the improvement of soil physical properties and level of macro and micronutrients (Mahida, 1981, Juwakar *et al.,* 1994).

Table 7(a): Effect of sewage on the yield of vegetable crops

Crops	Yields (t ha^{-1})			
	Well water	Untreated sewage	Primary treated sewage	Diluted (1:1) sewage
Cabbage	13.3	14.8	16.4	15.7
Cauliflower	16.4	18.2	19.7	16.9
Okra	3.1	3.4	4.8	4.0
Tomato	13.7	15.5	16.4	16.1
Brinjal	9.1	12.1	12.7	10.1
Potato	6.4	7.1	8.1	7.1

Source: Juwarkar (1994)

Table 7(b): Effect of sewage on the yield of vegetable crops

Crops	Yields (t ha^{-1}) undiluted sewage	Diluted (1:1) sewage	Canal water
Beet root	16.27	15.60	8.75
Carrot	11.75	8.72	9.71
Radish	8.33	6.14	7.26
Potato	9.33	7.00	6.12
Knol Khol	16.57	11.76	9.70
Cabbage	12.13	11.32	9.27
Cauliflower	9.09	7.08	9.96
French beans x	8.06	8.20	6.63
Tomato	13.38		10.01

Source: Mahida (1981)

In-organic sources

In-organics

Major nutrients

Vegetables need bulk of major nutrients. Requirement of nitrogen in most of the vegetable crops is quite high and brings a linear increase in yield. Increase in yield due to N fertilization could be attributed to luxuriant growth increased photosynthesis and better translocation of photosynthates. Requirement of phosphorus is not too high but is essential for plant health and is reported to have significant effect on the yield of vegetables. Potassium is required in higher quantity to improve the quality and shelf life of vegetables (root crops). Improper and imbalanced use of chemical fertilizers is hazardous with respect to over all soil health, yield and quality of vegetables. Sustainable yields can be harvested only if they are used in combination with other sources of plant nutrients like organic manures, compost and bio-fertilizers.

Secondary and micro nutrients

Adoption of improved technology in vegetable in vegetable production had decreased the level of secondary and micronutrients in most of the Indian soils, which is evident by response to addition of these nutrienys. Among secondary nutrients, requirement of sulphur is at par with that of phosphorus. Micronutrients along with secondary nutrients are known to improve the yield and quality of vegetables. So their application becomes indispensable for sustainable vegetable production.

For optimizing plant nutrient efficiency the time and method of application plays a key role. Nitrogenous fertilizers should be applied in split doses, while phosphatic and potassic fertilizers as basl treatments. Organic manures/composts should be well decomposed and applied at least 20-25 days prior to planting. Microbial inoculants should be applied 24-48 hours after chemical fertilizer application. Sustainability in vegetables also depends upon source of nutrients. Urea is an efficient source of N. Water soluble phosphatic fertilizers are more suitable for direct application in vegetable crops. K_2SO_4 is considered better option for K fertilization. As for organic sources are concerned their nutrient content depends on sources from which they are prepared. Poultry manure proved superior than sheep and farm yard manure

Advantages of Integrated Nutrient Management

The integrated nutrient management approach has several advantages:

- Integrated nutrient management is eco-friendly and economically profitable.
- Ensures, reduction in indiscriminate use of chemical fertilizers, which is often a cause of poor soil health and ecological hazards.
- Helps in the conservation of nutrients, benefiting the soil productivity, through favourable impact on chemical and biological properties of soil.
- INM ensures regular supply of macro, micro and secondary nutrients, besides improving soil biological health.
- Improves fertilizer use efficiency of applied fertilizers due to their favourable effect on soil properties, resulting in yield improvement.
- INM not only pushes the production and profitability, but it also helps in maintaining the soil fertility.
- INM had not only enhanced the yield of vegetable crops but had exhibited beneficial residual effect on succeeding crops.
- Ensures better quality as compared to sole applications.
- INM helps to release of N and other plant nutrients in the same pace as required by the crop.

Constraints in Adoption of INM

The technology developed for implementing INM does not find popular acceptance among the farmers upto the expected level owing to some constraints.

- Lack of awareness among the farmers regarding its utility and importance.
- INM is skill oriented and knowledge intensive technology needs much understanding of organics.
- Chemical fertilizers are still seen as a progressive approach by vegetable growers.
- Farming community does not find this approach acceptable, as it will take much time to change their attitude from the chemical fertilizers for ideological reason; the benefits have to be immediate for them.
- Lack of manpower, as INM is a knowledge intensive technology.
- Information on the use of organics and chemical fertilizers is lacking.
- Lack of proper coordination among teachers, Extension workers and farmers.
- Slow action of organic sources of plant nutrients.
- Inadequate supply of biofertilizers, vermicompost and other sources of plant nutrients coupled with their quality production.
- Lack of adequate literature and good extension activities faced by the farmer in the adoption of INM.

Future strategies

In order to provide a sound and logical support for successful implementation of INM in near future following steps need to be taken:-

- Greater awareness needs to be created among the farmers on farm resource generations and its proper recycling to serve rural needs.
- Soil test laboratories should be strengthened and up graded for soil/plant analysis (Macro/micro nutrients).
- Generation of block/District wise data base on nutrient resources.
- Greater awareness needs to be created among the farmers about the soil health, for monitoring soil nutrient status on regular basis through soil and plant analysis.
- Advantages of introduction of green legumes in the cropping systems should be promoted.
- Nutrient drain through crop, leaching, gaseous/volatalization, erosion etc, need to be evaluated.
- Enhancement of shelf life of biofertilizers, development of new strains through genetic engineering, development of techniques for assessing viability of bio-fertilizers. Popularization of biofertilizers are of paramount importance.
- Promotion/popularization of compost production.
- INM practice is for the farmers, by the farmers and of the farmers. Therefore it should be implemented in farmers participatory mode right from the planning, implementation and monitoring.
- Environmental concerns should be given sufficient prominence while developing INM technologies.

Conclusion

The prolonged and over usage of inorganic fertilizers had adversely effected, human and soil health, besides creating serious concerns of environmental pollution. The farmers are also looking for low cost input alternatives mainly of N fertilizer, which constitute a major component among the chemical fertilizers used in vegetable production. Hence the use of integrated nutrient management becomes indispensable for maximizing vegetable production, productivity, sustaining soil health and quality. In future we have to produce more vegetables for increasing population under limited plant nutrient resources. Sustainability advocates an integrated use of various production resources in a manner to mention/enhance productivity on one hand and to safeguard soil health and quality on the other. The crop produce/products received through INM will not only be higher in bulk but also high in quality in terms of nutrition.

References

1. Bhardwaj KKR, Gaur AC. Recycling of organic wastes ICAR Publications, 1985.

2. Chattoo MA, Ahmed N, Narayan S, Narayan R, Mir SA. Response of Garlic to biofertilizer application In: Souvenir: National Seminar on organic products and their future prospectus, October 21-22., 2003, SKUAST-K, Shalimar Srinagar, (J&K), 2003, 93.
3. Gaur AC. Phosphate solublizing micro-organism as biofertilizer. Omega Scientific Publisher, New Delhi, 1990, 176.
4. Gaur AC. Bulky organic manures and crop residues, fertilizers, organic manures recyclable wastes and biofertilizers. Development Corporation, New Delhi, 1992.
5. Juwakar AS, Shende A, Thawale PR, Ball AS. In: Fertilizers, organic manures, recyclable wastes and biofertilizers (Ed.) H. L. S. Tandon, 1994, 72.
6. Mahida UN. In: Water pollution and Disposal of waste water on land, Tata Mc Ground Hill Publication., New Delhi, 1981.
7. Rather SA, Ahmed N, Chattoo MA. Response of onion to microbial inoculation and chemical nitrogen. Haryana Journal of Horticultural Sciences. 2003; 32:270-271.
8. Sharma RC, Sharma HC. Usefulness of organic manure and their nitrogen fertilizer equivalent. Journal of Agricultural Sciences. 1988; 111:192-195.
9. Sharma SK. Changing agricultural scenario and new age strategies. In: ICAR Winter School on new dimensions in extension management of training. RAU, Biscanes, 2003, 1-7.
10. Singh, Yadvinder, Khind CS, Singh Y. Advances in Agronomy, 1991, 45-135.
11. Tandon HLS. Fertilizers and their integration with organic and biofertilizers. In: Fertilizer, organic manures, recycled wastes and biofertilizers (ed. H. L. S. Tandon). FDCO, New Delhi, 1992, 32-46.
12. Upadhyay NC, Sharma RC. Effect of alternative source of organic matter and crop residues on fertilizer economy in cow pea potato cumber system. In: Potato, Global Research and Development. 2000; II:147-150.