A review on integrated nutrient management in bulbous vegetable crops

C Subha Lakshmi and Ch. Chandra Sekhar

Abstract
Onion and garlic are two important bulbous vegetable crops cultivated in India. Both these crops have high domestic demand, medicinal value and good export potential and it could help earn handsome foreign exchange. The production of these bulbous crops is not sufficient enough to meet the demands for both domestic requirements and export. Among the various factors affecting yield of crops, nutrient management plays a major role in augmenting the yield. Integrated nutrient management can be considered as a viable option to enhance the production of these bulbous crops. The present review throws light on the results of few trials conducted to evaluate the effect of integrated nutrient management in bulbous vegetable crops viz. onion and garlic.

Keywords: onion, garlic, bulbous vegetables, integrated nutrient management

Introduction
Bulbous vegetable crops belong to family Alliaceae. The genus Allium is very large with more than 500 species, which are perennial and mostly bulbous plants. Out of these, only seven species are in cultivation. However, Allium cepa (onion) and Allium sativum (garlic) are the two major cultivated species grown all over the world. Both these crops have high medicinal value and tremendous export potential but the productivity of these crops is low. Nutrient management has major role to play in obtaining higher productivity. Sustainable production of crops cannot be maintained by using chemical fertilizers alone, because of deterioration in soil physical and biological environments (Khan et al., 2008) [1]. The integrated use of both organic manures and chemical fertilizers can be considered as the best approach to achieve higher productivity and enhanced soil fertility. Studies conducted revealed that the combined application of synthetic fertilizers and organic sources resulted in higher production and better quality of onion and garlic. The results of few trials conducted to evaluate the effect of integrated nutrient management in onion and garlic is reviewed here under:

1. Onion
Onion (Allium cepa L.) is one of the important vegetable cash crops cultivated extensively in India. Onion is an indispensable item in every kitchen as condiment and vegetable, therefore commands an extensive internal market. Onion is mainly used for its flavour and pungency. The chief component of pungency is ‘allyl propyl disulphide’. Onion is used for flavouring or seasoning the food, both at mature and immature stages, besides being used as salad and pickle. It is also used by processing industry for dehydration in the form of flakes and powder which are in great demand in the world market (Aagasimani, 2010) [2]. Although onion is usually regarded as a vegetable crop it has a long history of medicinal use. Onions are diuretic, applied on wounds, boils and bruises. It relieves heat sensation, insect bites and sore throat. The red pigment of onion bulb is due to presence of anthocyanin and yellow pigment is largely the flavonol quercetin. Quercetin protects against cataracts, cardiovascular disease and cancer. In addition, onion contains a variety of other naturally occurring chemicals known as organosulphur compounds that have been linked to lowering blood pressure and cholesterol levels. Onion is a rich source of calories, vitamins and minerals especially iron, phosphorus and calcium (Sampath Kumar et al., 2010) [3]. India ranks second in global onion production after China and accounts for around 20% of global production. However, Indian onion productivity is one of the lowest i.e. around 16.13 t/ha (Yadav et al., 2018) [4]. Nutrient management has key role to play in boosting the productivity and quality of onion which is a heavy feeder. The continuous use of inorganic fertilizers results in deficiency of micronutrients, imbalance in physico-chemical properties and sustainable crop production. Organic farming provides several benefits to the growers, it reduces production cost and it is an environment friendly method of cultivation. Addition of organic sources improves soil.
structure and enhances activities of useful soil organisms. Agricultural commodities obtained through organic cultivation are good for human health and also fetch high prices. But, organic sources alone are unable to give economic yield and it is vital to integrate inorganic fertilizers with organic sources to obtain financially viable yield of crops (Seran et al., 2010) [9]. The results of few trials conducted to study the effect of integrated nutrient management in onion are presented: An experiment was conducted by Patil et al. (2007) [8] to study the effect of integrated nutrient management on growth of onion at Central Farm, MPKV, Rahuri during 2004-05 in rabi season under irrigated conditions. The results revealed that the highest values of all growth attributes, number of umbels/plant, number of seeds/umbel, weight of seeds/umbel, 1000 seed weight and highest seed yield were obtained with the application of 120:60:60::N:P:K (RDF) kg/ha + 20t FYM/ha. Mahanesh et al. (2005) [7] noted that the plants provided with Azosirrillium + 100% NPK (125:50:125 kg/ha) recorded the highest plant height, number of leaves, neck thickness, bulb diameter, bulb weight and bulb yield under irrigated conditions during both kharif and rabi seasons. Jawadagi et al. (2012) [8] recorded maximum leaf length and number of leaves in onion with the application of RDF (125:50:125: N:P:K kg/ha) + FYM @ 30 t/ha. In another trial conducted by Shinde et al. (2013) [9], the treatment receiving 110:40:60:40 kg NPKS + 7.5t FYM + 2.5t vermicompost + biofertilizer (5 kg each of Azosirrillium + phosphobacteria) per hectare recorded the highest bulb yield indicating that the use of biofertilizers in combination with inorganic fertilizers and organic manures offers a great opportunity to increase the production in onion. Gupta et al. (1999) [10] revealed that FYM @ 7.2 t/ha along with ammonium sulphate @ 565 kg/ha was effective in increasing the growth, yield and quality contributing characters such as bulb colour, compactness, Total soluble solids (TSS) and dry matter. The application of neem seed powder along with 75% NPK through inorganic fertilizer gave the highest number of leaves per plant, bulb yield, bulb diameter and vitamin C content (Mondal et al., 2004) [11]. Santhosh Kumar et al. (2017) [12] conducted an experiment to study the effect of INM on growth and yield attributes of kharif onion at Horticulture Farm, SKN College of Agriculture, Jobner and revealed that the application of FYM @ 5 t/ha + vermicompost @ 2.5 t/ha + biofertilizers (Azospirillium + PSB) or application of N, P, K, S, Zn @ 100:50:100:20:10 kg/ha are worth recommended as both fetched comparable bulb yield and net returns. Keniseto Chuda Kanaujia et al. (2009) [13] recorded highest plant height, number of leaves per plant, neck thickness, bulb size, bulb yield and dry matter with the application of 50% NPK + 50% FYM. Abbey and Kanton (2003) [14] also reported maximum plant height, bulb weight, bulb diameter and bulb yield with the application of FYM coupled with fertilizers. Sankar et al. (2009) [15] reported that panchagavya + 100% recommended dose of NPK fertilizers helped in maintaining higher number of leaves in onion throughout the crop growth period. Hari et al. (2009) [16] recorded significantly higher onion bulb weight with the application of vermicompost @ 7 t/ha + 75% recommended nitrogenous fertilizers. Yadav et al. (2018) [4] reported that the practice of integrated nutrient management helped in obtaining maximum bulb yield in onion var. Agrifound Red. Balemia et al. (2007) [17] tested the efficacy of three Azotobacter strains as a potential supplement to nitrogenous fertilizer in improving growth and yield of onion cv. Pusa Madhavi. Application of 75kg N/ha along with inoculation of CBD-15 was found to have significantly increased the growth parameters and yield attributes, soil available nitrogen and nitrogen content in bulb. Devi and Limi Ado (2005) [18] evaluated the effects of different levels of nitrogen (90, 75, 60 and 45 kg N/ha) and phosphorus fertilizers (60, 45 and 30 kg P2O5/ha) along with biofertilizer (Azosirrillium @ 2 kg/ha) on the physiological growth parameters and yield of multiplier onion. The combination of Azosirrillium with 75 kg N, 45 kg P2O5 and 30 kg K2O/ha resulted in maximum LAI, plant height, neck thickness, net assimilation rate, dry matter production and maximum bulb yield. Khandelwal (2010) [19] reported that maximum number of leaves and plant height was observed with per hectare application of NPKS @ 110:40:60:40 kg along with 7.5t FYM + 2.5t poultry manure + 2.5t vermicompost + biofertilizer in onion crop. Ram Vachan and Tripathi (2018) [20] revealed that the bulb yield and yield components such as bulb length, bulb diameter and bulb weight, gross returns and net returns were highest with the application of 100% RDF + Azosirrillium + PSB. Jayathilake et al. (2002) [21] reported a significant increase in bulb weight and diameter on treatment with Azosirrillium + 50% recommended N through vermicompost + 50% N and 100% P, K through chemical fertilizers. Srinivasaraju (2011) [22] revealed that the application of 75% RDF + 1.65 t/ha vermicompost, Azotobacter and PSB (each 5 kg/ha) recorded the highest values of available N, P2O5 and K2O in soil after harvest of onion. In a field trial conducted by Reddy et al. (2011) [23] the application of vermicompost @ 10 t/ha + 120 kg N/ha resulted in highest bulb yield in onion-radish cropping system. Thangasamy et al. (2010) [24] revealed that in onion and garlic combined application of fertilizers along with organic manures and biofertilizers enhanced crop productivity, quality and soil health. Bhagwat (2014) [25] documented that highest plant height, number of leaves and neck thickness, polar diameter, equatorial diameter, average weight of bulb and total bulb yield were recorded in the treatment comprising 110:40:60:40 kg NPKS + 7.5t FYM + 2.5t poultry manure + 2.5t vermicompost per hectare. In another trial conducted by Maneesh Kumar (2015) [26] at Tikamgarh, results revealed that the application of 50% RDF + 50% vermicompost + PSB proved beneficial in obtaining the maximum number of onion bulbs and bulb weight. Mandal et al. (2015) [27] carried out a trial at Horticulture Farm, Institute of Agriculture, Sriniketan, West Bengal and reported that the treatment combination of 20t FYM/ha + State Recommended NPK (125:100:100 kg/ha) resulted in maximum growth parameters in onion. Basavaraja et al. (2007) [28] revealed that the combined application of coir pith based compost (CPBC) @ 15 t/ha along with press mud @ 15 t/ha + half the recommended dose of fertilizer resulted in highest bulb yield of onion. The results of study conducted by Singh et al. (2002) [29] revealed that the application of VAM in combination with recommended dose of NPK resulted in highest N and P uptake by onion bulbs. Chattoo et al. (2010) [30] reported that the highest bulb yield was registered with the application of poultry manure with 75:30:30 NPK kg/ha.

2. Garlic

Garlic (Allium sativum L.), widely known as Lahsun is the second most important bulb crop after onion used as spice or condiment with medicinal value throughout the world. Due to its strong odoriferous nature, garlic is commonly known as stinking rose (Sethi Neeraj et al., 2014) [31]. It possesses high nutritive value. Garlic is rich in protein, calcium, magnesium,
iron, potassium, zinc, arginine, saponins, polyphenols and selenium (Cardelle Corbas et al., 2010) [32]. It is a rich source of certain vitamins like Vitamin A, Vitamin B₆, B₃ and Vitamin C. Garlic is a natural health promoter and a wonder drug available from nature’s lap. Its preparations are useful in vitiated conditions of kapha and vata, cough, whooping cough, bronchitis, asthma, fever, facial paralysis, flatulence, constipation, atomic dyspepsia, helminthiasis, duodenal ulcers, pulmonary and laryngeal tuberculosis, ophthalmology, cardiology, fatigue, leucoderma, leprosy, hysteria, haemorrhoids, sciatica, otalgia, lumbago, swellings, splenopathy, hepatopathy, pneumonopathy, anthralgia, sore eyes, ear ache and dental caries (Kumar et al., 1997) [33]. Garlic bulb is reported to contain volatile oil, alliin and allilin. Volatile oil contains allecine (diallyl thiosulphinate), an active odour principle of garlic. Other major compounds present are diallyl disulphide, diallyl trisulphide, allyl methyl trisulphide and allyl methyl disulphide (Hussain et al., 1992) [34]. Garlic bulb is antiinflammatory, stimulant, diaphoretic, expectorant, diuretic, antispasmodic, astringent, antiparalytic, antileptonic, aperient, febrifuge, carminative, stomachic, alterative and emmenagogue. The essential oil is hypcholesterolemic, hypotensive, antitumour and anti diabetic. Diallyl disulphide and diallyl trisulphide from essential oil have larvicidal action. Bulbs also have antibacterial and antifungal activity (Joy et al., 1998) [35]. It possesses anti-cancer, antiviral and anti-inflammatory properties. Garlic is effective in the treatment of cardiovascular diseases and beneficial in ailments like arthritis, gout, stroke, cataract etc. This has gained it the title of superfood (Sethi Neeraj et al., 2014) [33]. Garlic supplements are made from whole fresh garlic, dried or freeze-dried garlic, garlic oil and aged garlic extracts (Amagasa et al., 2001) [36]. Garlic essential oil, garlic oil macerate, garlic powder and garlic extract are the four major garlic supplements. It is also used in the form of juice, syrup and tincture. Garlic is used in the form of pills to aid in digestion. Wine of garlic is used to treat baldness. Garlic crop assumes high importance due its high domestic demand, multiple medicinal uses and high export potential. Although the crop is commercially important the harvests from garlic are very low in India. Among the various constraints for low productivity in garlic imbalanced nutrition is the main limiting factor. Integrated nutrient management (INM) provides excellent opportunities to overcome all the imbalances besides sustaining soil health and enhancing crop production. The results of few trials conducted to evaluate the effect of integrated nutrient management in garlic are presented: Anand et al. (2017) [37] carried out a trial to study the influence of integrated nutrient management module for garlic at Horticulture Research Station, Nilgiris. The treatment combination of N:P:K:S.:75:40:40:40 kg/ha + 5t of FYM/ha + 2.5t of poultry manure/ha + 2.5t of vermicompost/ha performed better in terms of vegetative and yield characters of garlic. In another study conducted by Kuldeep Sevak et al. (2012) [38] at Horticulture Research Farm, Sardarkrushinagar results revealed that the application of 50% N in the form of FYM + 50% N in inorganic form recorded maximum number of cloves per bulb, maximum diameter of bulb, average weight of bulb, weight of 1000 cloves and bulb yield. An investigation was carried out to study the combined effect of PSB, Trichoderma and FYM with recommended dose of NPK on plant growth and bulb yield of garlic under solid wasteland condition. Maximum values of growth and yield parameters i.e. plant height (60.7 cm), leaf length (22.4 cm), root length (7.84 cm), number of leaves per plant (9.2), bulb weight (52.43 g), number of cloves per bulb (37.66), dry weight of whole plant (53.24 g) and bulb yield (60.86 q/ha) were obtained with the application of 100% recommended dose of NPK supplemented with the application of FYM and seed treatment with Trichoderma and PSB (Singh et al., 2015) [39]. Another trial was conducted by Vikram Singh et al. (2017) [40] during rabi season of 2014-15 to investigate the effect of different levels of biofertilizers (Azotobacter and PSB) in combination with three levels of NPK fertilizers on growth, yield and quality of garlic variety ‘GHC-1’. The application of biofertilizers alone and in combination resulted in significant improvement in plant height, number of leaves per plant, average bulb weight, bulb diameter, number of cloves per bulb, average clove weight, clove length, clove diameter, bulb yield, total soluble solids and dry matter of bulb over un-inoculated control. The increase in bulb yield was to the tune of 25.86, 12.99 and 9.81% with the combination of biofertilizers (Azotobacter + PSB), PSB and Azotobacter, respectively over un-inoculated control. The application of NPK fertilizers significantly increased all the growth, yield and quality parameters along with bulb yield over control with each incremental level of NPK. The interaction effects showed that bulb yield was increased in a linear manner with the application of bio-inoculants integrated with increasing levels of NPK fertilizers. The highest bulb yield (20.89 t/ha) was recorded when the plots were supplemented with 100% NPK + seedlings dipping of both the inoculants. Furthermore, it was observed that the yield obtained with the application of 75% NPK + Azotobacter + PSB was at par with that of recommended NPK (100%), thus resulting in net saving of 25% NPK fertilizers. Amit Kumar et al. (2015) [41] reported that the application of 60 kg N + 36 kg P₂O₅ + 60 kg K₂O per hectare + vermicompost @ 15 t/ha resulted in maximum plant height, diameter of stem, leaf length, leaf width and yield components. Gowda et al. (2007) [42] studied the influence of integrated nutrient management in garlic cv. G-282 and observed that the treatment comprising of 100% NPK + biofertilizer + vermicompost recorded highest plant height, number of leaves, girth of plant and bulb yield. An investigation was carried out by Nainwal et al. (2015) [43] to study the combined effect of biofertilizer viz. phosphate solubilizing bacteria (PSB) and Trichoderma supplemented with FYM and chemical fertilizers on plant growth and bulb yield of garlic (Allium sativum L.) under degraded land conditions. Maximum values of plant growth and yield parameters were obtained with the application of 100% recommended dose of NPK supplemented with FYM and seed treatment with Trichoderma and PSB. Kore et al. (2006) [44] studied response of garlic to the application of organic, inorganic sources and biofertilizers and observed that growth characters in response of plant height and number of leaves/plant and yield/ha were found maximum in treatment namely 10t FYM + 3kg Azotobacter + 3kg PSB + 75% RDF per hectare. Verma et al. (2013) [45] reported that the application of 7.5 t/ha vermicompost and 90 kg/ha sulphur individually produced maximum plant height, number of leaves per plant, chlorophyll content in leaves, fresh weight of leaves, neck thickness, number of cloves per bulb, weight of bulb, bulb diameter and bulb yield whereas the combined application of 5t/ha vermicompost along with 60 kg/ha sulphur was found to be superior with respect to weight of bulb, bulb yield and net returns of garlic. Damse et al. (2014) [46] documented that the application of 75:40:40:40 kg NPKS + 7.5t FYM + 3.75t poultry manure per hectare recorded the...
highest bulb yield and benefit cost ratio revealing that the application of reduced dose of chemical fertilizers along with combination of one or two organic sources was beneficial in garlic.

**Conclusion**

The practice of integrated nutrient management (INM) through combined application of organic sources and inorganic fertilizers can be considered as a viable option to enhance the crop growth, yield and quality parameters in bulbous vegetable crops viz. onion and garlic which would ultimately help the growers in earning better net returns.

**References**

27. Mandal J, Sharma A, Mandal S. Growth attributes of 
kharif onion (Allium cepa L.) as influenced by 
combination of organic and inorganic nutrients. 

28. Basavaraja PK, Sridhara S, Sushma AR, Harees GR. 
Effect of integrated nutrient management on onion yield 
and soil properties under chronic haplusterts of 

29. Singh A, Singh SP, Singh BP, Singh A. Effect of VAM 
and inorganic fertilizers on yield and N, P content and 

30. Chattoo MA, Najar GR, Mir SA, Faheema S. Effect of 
organic manures and inorganic fertilizers on growth, 
yield, nutrient uptake and economics of onion cv. Yellow 
14.

31. Sethi Neeraj, Kaura Sushila, Dilbaghi Neeraj, Parle 
Milind, Pal Minakshi. Garlic: A punjent wonder from 
2014; 5(7):523-529.

32. Cardelle Cobas A, Sorias AC, Corzo Martinez M, 
Villamiel M. A comprehensive survey of garlic 
consumption and health. New York: Nova Science 

33. Kumar NM, Abdul Khader JBM, Rangaswami P, 
Irulappan I. Introduction to spices, plantation crops, 
medicinal and aromatic plants. Oxford and IBH 

34. Hussain A, Virmani OP, Popli SP, Misra LN, Gupta MM, 
Srivastava GN et al. Dictionary of Indian Medicinal 
Plants. CIMAP, Lucknow. India. 1992, 546.

35. Joy PP, Thomas J, Samuel Mathew, Baby PS. Medicinal 

36. Amagase H, Petesch BL, Matsuura H, Kasuga S, Itakura 
Y. Intake of garlic and its bioactive components. Journal 
of Nutrition. 2001; 131(3S):955S-962S.

nutrient management for garlic under Nilgiris condition. 
International Journal of Current Microbiology and 

38. Kuldeep Sevak, Patel NM, Bhadhauria HS, Wankhade 
VR. Effect of integrated nutrient management on growth 
and yield of garlic (Allium sativum L.). Advance 
Research Journal of Crop Improvement. 2012; 3(2):164- 
166.

nutrient management on growth and yield of garlic under 
sodic wasteland conditions. Indian Journal of 

40. Vikram Singh, Sharma KC, Neeraj Thakur. Effect of 
integrated nutrient management on growth, yield and 
quality of garlic (Allium sativum L.) cv. GHC-1. Crop 

41. Amit Kumar, Sandeep Kumar, Aakansha Goswami, 
Singh B. Effect of INM on yield and yield components of 

42. Gowda MC, Vijaya Kumar M, Gowda APM. Influence of 
integrated nutrient management on growth, yield and 
quality of garlic cv. G-282. Crop Research. 2007; 33(1- 
3):144-147.

43. Nainwal RC, Singh D, Katiyar RS, Sharma L, Tewari 
SK. Response of garlic to integrated nutrient 
management practices in a sodic soil of Uttar Pradesh, 
India. Journal of Spices and Aromatic crops. 2015; 

44. Kore MS, Shembekar RZ, Chopde NK, Kuchanwar OD, 
Pillewan SS, Godse SB. Nutrient management in garlic. 

45. Verma S, Choudhary MR, Yadav BL, Jakhar ML. 
Influence of vermicompost and sulphur on growth and 
yield of garlic (Allium sativum L.) under semi-arid 

46. Damse DN, Bhalankar MN, Pawar PK. Effect of 
integrated nutrient management on growth and yield of 