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Influence of organic, inorganic fertilizers and biofertilizers on growth, yield and quality of onion (*Allium cepa* L.)

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Abstract
Onion (*Allium cepa* L.)" plant belongs to family Alliaceae and India is its center of origin and diversity. It is highly productive and usually finds a place as "king of kitchen". The growth, yield and bulb quality of onion are largely dependent on number of interacting factors. On the other hand onion is a long duration crop with high yield which removes large quantities of nutrients from the soil. Now-a-days demands for onion is increasing rapidly among the vegetable consumers in view of its better bulb size, and quality only one source of nutrients like chemical fertilizers, organic manures and biofertilizers cannot improve the production or maintain the production sustainability and soil health. Integrated plant nutrient management is the intelligent use of optimum combination of organic, inorganic and biological nutrient sources in a specific crop, cropping system and climatic situation so as to achieve and to sustain the optimum yield and to improve or to maintain the soil's physical, biological and chemical properties. Such a crop nutrition package has to be technically sound, economically attractive, practically feasible and environmentally safe. Therefore work done on the nutrient application to onion is reviewed in this paper.

Keywords: onion; biofertilizers, organic, inorganic

Introduction
Onion (*Allium cepa* L.) is a biennial or perennial herb belongs to family Alliaceae. It is one of the most important cash vegetable crop, among bulb crops and semi-perishable in nature. It can be transported to a long distance without much transit injury losses. India ranks second in onion production, which contribute 11.90 percent of total vegetable production of world. India produces about 19.40 million tonnes of onion from an area of 1.23 million hectares with productivity of 16.10MT ha^{-1} (Anonymous, 2013-14) [3]. The main onion growing states in our country are Maharashtra, Bihar, Karnataka, Gujarat, Andhra Pradesh, Uttar Pradesh, Orissa, Madhya Pradesh and Rajasthan. Nutrient supply approach for the crop by judicious mixture of organic manures along with the inorganic fertilizers has a number of agronomical and environmental efficiencies. This approach is not only the reliable way for obtaining fairly high productivity with substantial fertilizer economy but also ensures the concept of ecological soundness leading to sustainable agriculture (Swaminathan, 1987). The application of organic manures like FYM and poultry manure alone and in combination with NPK have been reported to decrease the bulk density, improve the soil porosity and increase water holding capacity (Maheswarappa *et al.*, 1999) [28]. An adequate supply of nitrogen is associated with vigorous vegetative growth and more efficient use of available inputs finally leading to higher productivity. The application of different doses of nitrogen increased plant growth and yield of onion (Patel *et al.*, 1992 and Sharma, 1992) [38]. Phosphorus has its beneficial effect on early root development, plant growth, yield and quality of crop produce (Balai, 2002) [4]. Metabolic activities of chloroplast are also influenced by potassium level in their organelles. Potassium also activates the fat producing enzymes in plant. Sulphur is a constituent of "Allyl propyl disulphide" which imparts the pungency in onion. The application of different doses of sulphur improves plant height, number of leaves, bulb diameter, bulb weight and yield of onion (Jana *et al.*, 1990) [23]. Biofertilizers are the inoculation of microorganism, which have capability of mobilizing nutrient elements from unavailable to available form through biological processes. The inoculation of PSB bio-fertilizer increases the yield of crops by 10 to 30 per cent (Tilak and Annapurna, 1993) [60].

Azospirillum inoculation helps the plants to attain better vegetative growth and also in saving inputs of nitrogenous fertilizers by 20-30%. Application of *Azospirillum* had significant effect on nutrient uptake, which may be helpful for increasing the crop production by way of enhancing the soil fertility (Subbian, 1994) [53, 54]. Use of biofertilizers not only supplement the nutrients but also improve the efficiency of applied nutrients (Somani *et al.*, 1990) [52]. Studies have also shown that integrated use of chemical fertilizers, organic residues like FYM, compost etc. and biofertilizers resulted in reduced losses of nutrients and environmental pollution (Ange, 1993 and Norbu, 1993) [2].

Influence of organic manures on growth, yield and quality of onion

Singh *et al.* (2001) [49] conducted a field experiment in Rajasthan, during rainy season to study the response of onion (cv. N-53) with integrated application of N (0, 60, 90, 120 and 150 kg ha^{-1}) and FYM (0, 5, 10 and 15 t ha^{-1}). The average bulb yield increased significantly up to 120 kg N ha^{-1} and FYM at 10 t ha^{-1}.Ethel *et al.* (2009) [15] recorded significantly higher plant height of onion with FYM @ 30 t ha^{-1} (30.3 - 45.2 cm) compared to other organic manures. Sharma *et al.* (2009) [45] conducted an experiment on okra, onion sequence and reported highest yield (11.10 and 11.63 t ha^{-1}) of okra under the treatment comprising 100% recommended dose of NPK + vermicompost @ 10 t ha^{-1}, during 2003 and 2004, respectively. Further, yield of onion bulb was obtained at par with the application of vermicompost @ 12.5 t ha^{-1} + 100% NPK (8.38 and 12.56 t ha^{-1}) and farm yard manure @ 25 t ha^{-1} + 100% NPK (8.86 and 12.08 t ha^{-1}) during 2003-04 and 2004-05. Vu Tien Khang *et al.* (2011) [63] investigated and found that the production potential of soyabean-onion cropping sequence was maximum at 100% (302.8 q onion bulb ha^{-1}) recommended dose of fertilizer NPK (100:50:50 kg ha^{-1} for onion). Similarly, the application of 100% organic source of nutrient through FYM, vermicompost, neem seed cake, *Azotobacter*, PSB and trap crop gave the maximum yield of onion and also improved the fertility status of soil in better way than control and 100% RD of NPK. ShaymaaI shedeed *et al.* (2014) [46] reported that fresh and dry weight of bulb, bulb diameter, plant height and chlorophyll content of onion were found significantly superior when organic matter was applied in combination of biofertilizer. Zakari *et al.* (2014) [73] reported that the three types of organic manures (poultry dropping, FYM, Cowdung) used in the study significantly increased yield and yield components of garlic. The use of poultry dropping as organic manure @ 7.5-10 t ha^{-1} recorded optimum yield attributes and yield of garlic. Meena *et al.* (2015) [32] reported that growth attributes, TSS and nitrogen content in onion bulb increased significantly with the combined application of FYM @ 5 t ha^{-1} + vermicompost @ 2.5 t ha^{-1}. However, phosphorus and sulphur content of bulb were significantly increased with the application of FYM @ 5 t ha^{-1} + poultry manure @ 2.5 t ha^{-1}. Bulb inoculation with *Azospirillum* + PSB also significantly increased both growth and quality attributes of onion over other treatments. Farooq *et al.* (2015) [16] observed that the application of 60 t FYM + 5 t poultry manure ha^{-1} increased the plant height, number of leaves, bulb diameter, bulb weight, bulb yield and productivity of onion as compared to other treatments.

Influence of Inorganic manures on growth, yield and quality of onion

Singh and Chaure (1999) [47] reported that application of nitrogen @ 150 kg ha^{-1} recorded higher leaf length, number of leaves per plant, bolting percentage, bulb weight and bulb yield of onion. Prakash *et al.* (2000) [40] revealed that increasing levels of nitrogen (0 to 150 kg ha^{-1}) and FYM (0 to 20 t ha^{-1}) brought marked improvement in bulb yield, yield attributes and TSS content in bulb. The highest bulb yield (461.69 q ha^{-1}), bulb weight (105 g), bulb diameter (5.9 cm) and TSS (10.4 %) in onion were recorded with the nitrogen 150 kg ha^{-1}. Application of 150 kg N + FYM @ 20 t ha^{-1} registered highest gross return (` 195707).Singh *et al.* (2000) [48] found that fertility levels brought about significant improvement in height and number of leaves per plant. The maximum height and number of leaves of onion cv. Agri Found Dark Red were recorded with the application of medium fertility levels i.e. 200+ 80 + 120 kg NPK ha^{-1} in *kharif* season crop. Naruka (2002) [36] reported maximum values for moisture, protein, nitrogen, potassium, sulphur, ascorbic acid and volatile oil contents in garlic bulb with application of nitrogen. Sharma *et al.* (2002) [44] studied the effect of sulphur application @ 0, 15, 30, 45 and 60 kg ha^{-1} on onion *cv.* Pusa Red grown in light and heavy textured soil in a pot experiment and reported that plant height, bulb diameter and bulb yield increased significantly with application of sulphur up to 30 kg ha^{-1} in heavy and up to 45 kg ha^{-1} in light textured soils. Tiwari *et al.* (2002) [61] investigated the effect of N (0, 40, 80 and 120 kg ha^{-1}) on yield attributes of onion cv. Pusa Red and found that plant height, length of flower stalk, number of umbels per bulb, test weight, purple blotch incidence and seed yield increased with increasing rates of N upto 80 kg ha^{-1}. Channagoudra (2004) [7] reported that the application of 40 kg S ha^{-1} recorded significantly higher bulb yield (170.6 q ha^{-1}) over 20 kg S ha^{-1} (143.36 q ha^{-1}) and no sulphur application (130.46 q ha^{-1}) but was at par with application of 60 kg S ha^{-1} (161.94 q ha^{-1}) in onion crop. Jilani *et al.* (2004) [26] investigated the effect of different levels of nitrogen (0, 80, 120, 160 and 180 kg N ha^{-1}) on three onion cultivars (Faisalbad Early, Phulkara and Sheth Alam). The results revealed that leaf length, cull percentage and total yield were found significantly superior at different levels of nitrogen in all three varieties. However, at 120 kg N ha^{-1} proved to be the best for all the parameters. Singh *et al.* (2004) [51] recorded that plant height at harvest (51.43 cm), leaf length (28.22 cm), fresh weight of leaves (25.21 g) were highest in 150 kg N ha^{-1}. However, the number of leaves per plant were significantly higher upto 100 kg N per ha. Similarly, the plant height at harvest (52 cm), leaf length (29 cm), fresh weight of leaves (24.60 g) were observed maximum with application of 120 kg K per ha. Chowdappan (1972) also observed that the large sized bulbs were obtained in response to N at the maximum level of 60 kg ha^{-1} and Pat an intermediate level of 30 kg ha^{-1}.Reddy and Reddy (2005) [41] studied the effect of different levels of vermicompost (0, 10, 20 and 30 t ha^{-1}) and nitrogenous fertilizer (0, 50, 100, 150 and 200 kg ha^{-1}) on the growth and yield of onion (cv. N-53) and found that plant height, number of leaves per plant, leaf area, bulb length, diameter, weight and yield of onion increased significantly with increasing levels of vermicompost (from 10 to 30 t ha^{-1}) and nitrogen fertilizer (from 50 to 200 kg ha^{-1}). Singh *et al.* (2005) [50] observed the maximum TSS content of 12.49% and 12.50% in onion along with the application of nitrogen @ 150 and potassium @ 120 kg ha^{-1}, respectively. Channagoudra and Janawade (2006) [8] reported that the application of 40 kg sulphur ha^{-1} recorded significantly higher bulb yield of onion (170.6 q ha^{-1}) over 20 kg sulphur ha^{-1} (143.36 q ha^{-1}) and no sulphur application

(130.46 q ha^{-1}). Garhwal *et al.* (2007) [18] reported that the plant height, number of branches branches per plant and leaf area of okra significantly enhanced with the application of nitrogen (90 kg ha^{-1}) through vermicompost and urea as compared to control. Nasreen *et al.* (2009) [37] revealed that application of fertilizers @ 150 kg N, 50 kg P, 100 kg K, 40 kg S and 5 kg Zn/ha were economical for higher garlic production. Chattoo *et al.* (2010) [10] studied the effect of organic manures and inorganic fertilizers on growth, yield and economics of onion cv. Yellow Globe. They concluded that higher bulb yield (33.67 t ha^{-1}) was registered in the application of poultry manure with 75: 30: 30 NPK kg ha^{-1}. Seran *et al.* (2010) reported that the application of half fold of the RDF of inorganic fertilizer and compost at the rate of inorganic fertilizers and compost @ 4 t ha^{-1} gave profitable yield (4.75 t ha^{-1}) and this combination possibly reduced the cost of production in the cultivation of onion. Thangasamy *et al.* (2010) [57] revealed that combined application of fertilizers along with organic manures and bio-fertilizers enhanced crop productivity, soil health and quality in onion as well as garlic. Hence, balanced application of plant nutrients through integrated plant nutrient supply system was most important to maximize onion and garlic productivity and nutrient use efficiency. Zeinani *et al.* (2010) [75] observed that the highest yield and bulb mean weight was obtained at 200 kg ha^{-1} sulphur along with *Thiobacillus* inoculation. Sulphur had positive effect on the total soluble solids (TSS), bulb dry matter (DM), bulb firmness and pyruvic acid of the onion bulbs. Increasing the level of sulphur up to 150 kg ha^{-1} resulted in increase of TSS, DM, bulb firmness and pyruvic acid of the bulbs. Dudhat *et al. (*2011) [13] studied the effect of sources and levels of sulphur fertilizers on bulb yield of onion during the *rabi* season of year 2003-04 to 2005-06 and recorded significantly higher bulb yield of onion (415.63 q ha^{-1}). Among various sources, the maximum net returns of 35676 ` ha^{-1} and benefit cost ratio of 0.87 were also recorded by use of elemental sulphur @ 60 kg ha^{-1}. Hariyappa *et al.* (2011) [22] studied the effect of potassium and sulphur on growth, yield and quality parameters of onion. Application of 125 kg K_2O + 30 kg S ha^{-1} was found more remunerative and resulted higher uptake of nitrogen (202.47 kg ha^{-1}), phosphorus (25 kg ha^{-1}), potassium (111.13 kg ha^{-1}) and sulphur (43.24 kg ha^{-1}) as well as higher potassium and sulhpur content in both leaf and bulb of onion. Mandal *et al.* (2013) [31] reported that the application of 50% vermicompost + 50% NPK recorded maximum plant height, neck diameter, bulb polar and equatorial diameter, whole plant weight, average bulb weight and bulb yield of onion over other treatments. Mishu *et al.* (2013) [33] studied the effect of different doses of sulphur on growth and yield performances of onion. The maximum yield (10.65 t ha^{-1}) and sulphur content (0.49%) of onion bulb were observed in 40 kg S ha^{-1} at 45 and 85 days after transplanting. Shaktawat *et al.* (2013) [43] found that the application of 2.5 t vermicompost + 100 kg N + 50 kg P_2O_5 + 50 kg K_2O ha^{-1} significantly increased yield of garlic as compared to no use of balanced fertilizers. Thangasamy *et al.* (2013) [58] also revealed that sulphur application increased marketable bulb yield, sulphur uptake and pungency level over no sulphur treatment. The pyruvic acid content had significant and positive correlation with sulphur application (r^2=0.735**). Tripathy *et al.* (2013) [62] reported that application of sulphur @ 30 kg ha^{-1} recorded significantly higher plant height (54.51 cm), number of leaves per plant (14.80), polar diameter (5.17 cm), equatorial diameter (5.17 cm), average bulb weight (60.83 g), total bulb yield (211.23 q ha^{-1}) and TSS (11.90%) than other levels. Diriba-Shiferaw G. *et al.* (2014) [12] reported that the combined application of 92 kg N + 40 kg P + 30 kg S ha^{-1} and 138 kg N + 40 kg P + 60 kg S ha^{-1} led to the attainment of optimum bulb quality attributes on andosol and vertisols, respectively. However, application of 92 kg N + 40 kg P + 30 kg S ha^{-1} was found to be economical for farmers. Ibrahim Abuga (2014) concluded that application of NPK @ 10 g/polybag boosted the performance of onion.

Influence of bio-fertilizers on growth, yield and quality of onion

Field experiments conducted by Musmade and Konde (1987) [34] to study the influence of inoculation of *Azospirillum brasilense* and *Azospirillum lopoferum* under different nitrogen levels and revealed that inoculation with bio-fertilizers significantly increased the growth parameters viz., plant height, number of leaves per plant, dry matter, yield and nitrogen content of onion bulbs. Gurubatham *et al.* (1989) [21] reported that seed inoculated with *Azospirillum* increased yield from 19.1 t ha^{-1} to 20.5 t ha^{-1} in onion cv. N-53. Poopathi (1994) reported that plant height, number of branches per plant, dry matter production in tomato were more with combined application of *Azospirillum* and *phosphobacteria*. Subbian (1994) [53, 54] found that application of *Azospirillum brasilense* by seed treatment and seedling dipping of onion significantly affected the nutrient uptake. Wange *et al.* (1995) [66] reported that cabbage crop inoculated with *Azotobacter* along with application of N @ 200 kg ha^{-1} or with *Azospirillum* or *Azospirillum* + *Azotobacter* along with application of N @ 220 kg ha^{-1} both produced highest yield and gross return than rest of the treatments. EI- gamal (1996) [14] carried out field trial at EINAHD region of Egypt to study the effect of inoculation of seed tubers with HALEX2 (a mixture of N fixing bacteria of genera *Azotobacter*, *Azospirillum* and Klebsiella) and observed that inoculation with HALEX2 resulted in taller plants with higher leaf N content, dry matter, protein and carotene content of potato tubers. Warade *et al.* (1996) [67] also reported that highest bulb yield of onion (27.7 t ha^{-1}) was obtained with 40 t FYM ha^{-1} + NPK (100, 50 and 50 kg ha^{-1}, respectively) + *Azospirillum*. The field trail conducted at Nasik with cv. Agrifound Light Red to know the effect of biofetilizers in combination with nitrogen through organic and inorganic sources on yield and quality and found that application of *Azotobacter* as a seedling dip (1500 g in 5 litre of water) along with 50% recommended dose of nitrogen gave the highest marketable bulb yield (230.62 q ha^{-1}) with a net returns of ` 37,196 ha^{-1} (Bhonde *et al.*, 1997) [5]. Thilakavathy and Ramaswamy (1998) observed that highest bulb yield of multipier onion (18.37 t ha^{-1}) was recorded with 45 kg N + 45 kg P + 30 kg ha^{-1} *Azospirillum* and phosphorus bacteria as compared to control (16.59 t ha^{-1}). Wange (1998) [65] investigated the effect of inorganic N, alone or in combination with biofertilizer (*Azospirillum*), on the growth and yield of onion. Application of *Azospirillum* + N @ 50 or 75 kg ha^{-1} and *Azospirillum* + N @ 50 kg ha^{-1} increased the growth and yield of onion. Fentahum and Singh (1999) obtained the highest onion bulb diameter horizontal (5.38 cm) and vertical (4.06 cm) by application of *Azospirillum brasilense* + VAM + 50 kg N. The treatment VAM + *Azospirillum brasilense* + 25 kg P produced the highest number of bulbs, shoot dry weight (8.28 g) and number of leaves (8.1). Muthuramalingam *et al.*, (2001) [35] stated that the application of 60:60:30 kg NPK ha^{-1} along with FYM @ 25 t ha^{-1}, *Azospirillum* @ 2 kg ha^{-1} and Phosphobacterium @ 2 kg ha^{-1} with close spacing of 45 × 5

cm recorded the highest plant height (48.5 cm) and bulb length (5.70 cm) at 100 and 135 DAS in onion. Alkaff *et al.* (2002) [1] obtained the highest onion bulb weight (44%) as noted with the mineral fertilizer. However the highest total yield was recorded with FYM, followed by the mineral fertilizer and biofertilizer. Jayathilake *et al.* (2002) [24] revealed that plant height, number of leaves per plant, bulb weight and bulb yield in onion were recorded maximum with the application of bio-fertilizer (*Azotobacter* or *Azospirillum*) in combination with 50 per cent of recommended nitrogen through organic manures (FYM or vermicompost) and rest of the NPK through chemical fertilizers. Sule *et al.* (2002) [55] studied the impact of biofertilizers (*Azospirillum, Azotobacter, Rhizobium* and phosphate solubilizing bacteria) on the productivity of onion. The positive results of average productivity (20.05 & 18.13 t ha^{-1}) were recorded under inoculation of bio-fertilizers and no inoculation. Yadav *et al.* (2002) [68, 70, 71] reported that application of *Azospirillum* gave significantly higher bulb yield of onion (320.99 q ha^{-1}) as compared to without *Azospirillum* (306.1 q ha^{-1}). Devi *et al.* (2003) reported that higher yields of onion (163.41 q ha^{-1}) and net returns (` 85,807 ha^{-1}) were obtained with the application of 75 kg N + 45 kg P ha^{-1} + *Azospirillum* + phosphatika. Jayathilake *et al.* (2003) [25] conducted a field experiment to know the effect of integrated nutrient management using biofertilizers in onion (cv. N-53). Application of biofertilizers, organic manures and chemical fertilizers increased the bulb yield by 22 per cent over control. Yadav *et al.* (2003) [69] reported that inoculation of *Azotobacter* alone or in combination with N @ 50, 75,100 kg ha^{-1}significantly increased seed yield of onion cv. Hissar-2 over the uninoculated control. The maximum plant height (10% more over the control) and number of umbels per plant (53% over the control) were also obtained with application of *Azotobacter* MSX-9 in combination with 75 and 100 kg N ha^{-1}, respectively. Gunjun *et al.* (2005) observed the effect of four levels of N (25, 50, 75 and 100 kg ha^{-1}) and two sources of biofertilizers *i.e. Azatobacter* and *Azospirillum* as seedling dip, seed dressing and soil treatment. The treatment combination of 100 kg N + *Azatobacter* as seedling dip gave the highest bulb yield and fresh weight of bulb. Similarly, Yadav *et al.* (2005) [50, 72] also concluded that 75% recommended dose of nitrogen alongwith *Azospirillum* application gave significantly highest onion bulb yield (328.49 q ha^{-1}). Highest nutrient content and net returns of ` 31287 ha^{-1} with B: C ratio (10:1). Application of 100 per cent dose of NPK + *Azospirillum* + PSB + *Trichoderma viridae* + vermicompost (6.25 t ha^{-1}) recorded maximum plant height, number of leaves per plant and plant girth in garlic. Further, fresh and dry weight of the bulbs, bulb yield, TSS and sulphur content of the bulbs of garlic also found maximum in the same treatment (Chandre Gowda *et al.*, 2007) [6]. Chattoo *et al.* (2007) [9] observed that bio-fertilizers had a beneficial effect on growth, yield and quality attributes of garlic. The results were found more effective, when *Azatobacter* + phosphobacteria was applied in conjugation with 75 kg N + 45 kg P_2O_5 ha^{-1} resulting in a fertilizer economy of 25% without affecting crop yield. Ghanti *et al.* (2009) [19] concluded that *Azotobacter* + *Azospirillum* combination is the best for onion as compared to other as far as the sustainability in production and environment considerations. Waghmode *et al.* (2010) [64] found that the application of GA (100 ppm) along with biofertilizer *Azospirillum* + PSB @ 6 kg ha^{-1} and VAM @ 10 kg ha^{-1} was effective to increase yield of onion.

Conclusion

The literature available reveals that application of organic, inorganic and bio fertilizer help in better vegetative growth, seedling stands, improved yield and quality of onion. Thus, it can be concluded that organic, inorganic and bio fertilizer can be effectively used for improving growth, yield, and quality of onion if applied at proper time and manner in suitable doses or concentrations –

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