REVIEW OF LITERATURE
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Among the several factors responsible for increasing the production of onion, soil conditioners and nitrogen play an important role. An attempt has been made to review the research work done on these aspects in India and abroad under following heads:

2.1 Effect of soil conditioners

Soil organic matter is one of the most important natural resources used for maintaining soil fertility, productivity and thereby, increasing the crop production.

2.1.1 Effect on growth

Singh and Tewari (1968) studied the effect of source of organic manures i.e. leaf mould, castor cake, neem cake, farm yard manure (FYM) and nitrogen levels (50 and 100 kg N ha\(^{-1}\)) on growth characteristics of garlic at Varanasi on alluvial soil. The results revealed that at the last phase FYM showed the highest efficiency of growing plant at 50 days, however the best growth performance of stem was noticed in plant treated with neem cake. Number of leaves at 100 days was significantly reduced when castor cake was applied as organic manure.

Reddy (1985) conducted a field experiment during the *rabi* season on alfisol at Rajendranagar, Hyderabad and found that an application of FYM to onion crop @ 25 tonnes ha\(^{-1}\) with 60 kg N ha\(^{-1}\) as basal dressing and 15-60 kg P\(_2\)O\(_5\) ha\(^{-1}\) either broadcasted or incorporated had no significant effect during the early stages of growth.
Thanunathan et al. (1997) carried out an investigation to study the effect of different sources of organic amendments on growth and yield of onion in mine spoil with twelve treatment combinations of sail, mine spail, vermicompost (made from coir or water hyacinth and FYM). An application of organic manure significantly increased the plant height, number of leaves, root length and bulb circumference.

2.1.2 Effect on yield

Chroboczek (1962) found that FYM produced better yield than mineral fertilizer did and yield of leeks, onion and beans were good without rotation.

Haworth (1963) studied the effect of application of FYM + NPK or nitrogen alone on yields of spring cabbage and leeks on sandy loam soil and reported that higher yields of all crops were obtained with application of FYM + NPK as compared with application of nitrogen alone.

Sandhu (1964) on sandy loam soil of IARI, New Delhi observed that the nitrogen sources like ammonium sulphate, ammonium nitrate, ammonium chloride and urea, each at four levels were equally effective when applied after a basal dressing of 12 tonnes FYM per hectare.

Misra and Prasad (1966) carried out an experiment at Varanasi and observed that an application of sulphur through fertilizer and soil conditioners like gypsum increased the yield of onion at 100 lbs per acre may be related to the pH of soil.
Singh and Tewari (1968) reported that castor cake produced the highest yield of garlic bulbs per hectare with nitrogen application @ 100 kg ha$^{-1}$.

Narang and Dastane (1971) conducted an experiment at IARI, New Delhi with a local cv. Red onion in greenhouse as well as in field condition, where sulphur was applied through ammonium sulphate and gypsum and reported that the yield of bulb onion was influenced by different sources of sulphur, however, higher level of sulphur significantly decreased the yield of bulb onion.

Muzika (1986) concluded that the best results were observed with application of FYM @ 30 t ha$^{-1}$ + N : P$_2$O$_5$ : K$_2$O at 120 : 90 : 90 kg ha$^{-1}$, which increased the yield of onion either grown as a one or a two years crop.

Ranganna et al. (1991) applied FYM at 10 t ha$^{-1}$ few weeks before sowing of crops and incorporated into the soil and observed the greatest percentage increase in ragi (31.42 q ha$^{-1}$) with biogas spent sludge compared with FYM (21.67 q ha$^{-1}$) followed by garlic (24.65 % increase). The results further showed that biogas spent sludge had a higher mean yield than FYM application.

Suchorska (1992) while working with onion cv. Wolska, beet root cv. Czer-Wanalcula grown on clay soil fertilized with Nowmin alone and with FYM @ 50 t ha$^{-1}$, observed that the highest yield of all the three crops were obtained on plots treated with nowmin demonstrating that it can be successfully used as FYM substitute.

Kropisz (1992) studied the influence of fertilization with FYM @ 25 t ha$^{-1}$ on yield of vegetables and their content of mineral elements. He found that the highest average yield was obtained from
plot receiving FYM + NPK which were 50.2, 28.3 and 31.5 t ha\(^{-1}\) for cabbage, onion and carrot, respectively.

Singh et al. (1997) assessed an effect of different organic manures and inorganic fertilizers on yield of *rabi* onion. The organic manures were green manure, FYM @ 25 t ha\(^{-1}\) and vermicompost (2 t ha\(^{-1}\)); while an inorganic fertilizers were 100 kg N, 100 kg N + 50 kg P, 100 kg N + 25 kg P + 25 kg K and 100 kg N + 50 kg P + 50 kg K. The results indicated that FYM produced the highest gross and marketable yield. FYM + NPK gave the highest marketable yield of bulbs while FYM alone gave better yield as compared to NPK fertilizer only at low soil moisture (Rumpel, 1998).

### 2.2 Effect of levels of nitrogen

#### 2.2.1 Effect on growth

Purewal and Dargan (1961) reported that an application of nitrogen increased the height of plant, number of leaves as well as individual bulb weight significantly in garlic cv. Local Selection.

Singh and Tewari (1968) observed an outstanding effect of nitrogen on fresh and dry weight of plant and leaf area, whereas height of plant and number of leaves were remained unaffected. The maximum roots were produced by application of 50 kg N ha\(^{-1}\), which was significantly better than the control and application of 100 kg nitrogen at 150 days.

Pande et al. (1969) conducted an experiment at Rewa (Madhya Pradesh) on a well drained clay loam soil and found that the growth increased with increase in doses of nitrogen upto 168 kg N ha\(^{-1}\). An application of nitrogen significantly increased the plant height,
of leaves, fresh weight of bulb and bulb weight. The increase in various growth characters might be due to an application of N, which is useful for the development and function of protoplasm.

Pande and Mundra (1971) revealed that 134.4 kg N ha\(^{-1}\) significantly increased the height of plant, number of leaves, diameter of bulbs and also the fresh as well as dry weight of bulb in cv. Poona-1.

Das et al. (1972) while studying an influence of varying doses of nitrogen on Red Globe onion, observed that an application of nitrogen had significant effect on various growth characters of onion plant such as plant height, number of leaves, stem thickness and leaf area.

Hari Om et al. (1978) observed that an application of nitrogen @ 75 kg ha\(^{-1}\) exhibited its superiority in increasing the height of plant, number of leaves, diameter of plant, size of bulb and number of cloves of garlic bulbs.

Maurya and Bhuyan (1982) studied an effect of different levels of nitrogen and plant population during winter season at Muzafferpur (Bihar) and found that an application of nitrogen influenced significantly the height of garlic plants. The maximum height of 45.75 cm was observed by application of nitrogen @ 20 kg ha\(^{-1}\), while the minimum height of 40.85 cm was recorded control. However, the maximum number of leaves (6.63) were reported under the treatment of 200 kg N ha\(^{-1}\) and the minimum under control (0 kg N ha\(^{-1}\)).

Patil et al. (1983) conducted an experiment during rabi season at Parbhani on black vertisol and reported that height of the onion plant increased significantly by an application of nitrogen at 30,
45, 60, 75 and 90 days after transplanting. They further noted that as the dose of nitrogen increased from 0 to 150 kg ha$^{-1}$, there was a significant increase in number of leaves per plant at all the growth stages.

Batra and Pandita (1984) observed that the plant height and number of leaves per plant showed increasing trend under different levels of nitrogen in onion cv. Hisar-2. Similarly, Patil et al. (1984) also reported the largest bulb diameter (6.344 cm) by an application of nitrogen @ 150 kg ha$^{-1}$ as compared to control.

Das et al. (1985) reported that an application of nitrogen significantly promoted the plant height, number of leaves and also increased the diameter of garlic bulbs.

Reddy (1985) revealed that an application of nitrogen @ 60 kg ha$^{-1}$ as a basal dressing and P$_2$O$_5$ @ 15-60 kg ha$^{-1}$ either broadcasted or incorporated, produced the maximum plant height and number of leaves.

Nehra et al. (1988) at Hissar studied on onion cv. Hisar-2 and concluded that the plant height, number of sprouts, scapes and number of leaves per plant were appreciably favoured under control. Whereas, the differences by application of 40 and 80 kg N ha$^{-1}$ were not significant except, 80 kg N ha$^{-1}$ which increased the number of leaves per plant over 40 kg N ha$^{-1}$.

Pandey and Ekpo (1991) studied the effect of fertilizer and spacing on onion cv. Barna Local and observed that the highest plant height (63.2 cm) and number of leaves per plant (13.0) at 90 days after transplanting were obtained with an application of nitrogen @ 160 kg ha$^{-1}$. 
Vachhani and Patel (1996) conducted an experiment at Navsari during *rabi* season on onion cv. Pusa Red. The results revealed that the plant height and number of leaves per plant were the highest with an application of 150 kg N ha\(^{-1}\). Similarly, Singh *et al.* (1994) observed higher plant growth by application of 100 kg N ha\(^{-1}\).

### 2.2 Effect of level of nitrogen

#### 2.2.2 Effect on yield

A dose of 67.25 kg N ha\(^{-1}\) recorded the highest increase of 82.2 per cent in onion yield over unfertilized crop (Sandhu, 1964).

Geissler and Kaufmann (1965) concluded that a solution of ammonium nitrate and ammonia was superior to solid nitrogen fertilizers in white cabbage, lettuce and leeks; whereas lower yield was obtained with a solution of ammonia alone.

Sambamurthy and Rama Rao (1965) at Anantharajupet, Andhra Pradesh obtained remarkable increase in the yield of onion bulb with the increase in quantity of nitrogen.

Srivastava *et al.* (1965) reported that the highest level of 99 kg N ha\(^{-1}\) was found the most effective for onion bulb production under Almora conditions. Similarly, Bhoyar (1966) from Anand reported the significant increase in size and yield of onion bulbs by application of 90 and 112 kg N ha\(^{-1}\) over that of 45 and 67.50 kg N ha\(^{-1}\). Likewise, Wayse (1967) working at Poona during *rabi* season reported that an application of 99 kg N ha\(^{-1}\) had significantly increased the yield of onion cv. N 2071 by about 50 per cent over control.

Polach and Vlcek (1967) studied the effect of different rates of N, P and K on onion yield, quality and its storage life and
observed that nitrogen application @ 0-240 kg ha\(^{-1}\) had no marked effect on quality or storage life whereas nitrogen application at all rates increased the yield of onion.

Lazo et al. (1969) reported that the single application of 50 kg N ha\(^{-1}\) and unfertilized plots both produced low yields of onion cv. Garnex compared to other treatments whereas the fertilizers applied at 100 : 0 : 0 and 100 : 100 : 0 NPK kg ha\(^{-1}\) gave the highest yields.

Singh and Singh (1969) conducted an experiment at Rewa (Madhya Pradesh) during rabi season on clay loam soil and observed that among different nitrogen levels i.e. 0, 84, 168 and 252 kg ha\(^{-1}\), the maximum yield was recorded by 84 kg N ha\(^{-1}\) followed by 168 and 252 kg N ha\(^{-1}\). Likewise, Pande et al. (1969) reported that the yield of onion was increased with increasing doses of nitrogen upto 168 kg ha\(^{-1}\). Similarly, Singh and Kumar (1969) found that the total and marketable bulb yield were increased with the higher dose of nitrogen and phosphorus and there was also a corresponding increase in bulb size.

Mellu and Randhawa (1970) reported that an application of nitrogen @ 50 kg ha\(^{-1}\) to onion increased the yield (54.64 q ha\(^{-1}\)) over control.

Narang and Dastane (1971) observed that nitrogen application tremendously increased the yield of onion bulbs on medium soils having 0.444 per cent total nitrogen.

Singh (1972) observed that the fertilizer application in onion cv. Patna Red @ 90 kg N ha\(^{-1}\) was the most beneficial for ascertaining the bigger harvest with bigger size and higher weight of bulb per plant.
Bhuiya et al. (1974) conducted a trial on onion cv. Local Red and found that an application of nitrogen significantly increased the onion bulb yield. They further reported that the increase in yield due to application of 50 kg N ha\(^{-1}\) over control was 1.80 per cent with yield increase of 3.49 q ha\(^{-1}\). Similarly, Randhawa and Singh (1974) also found increase in yield of onion cv. Punjab Selection with an increase in the dose of nitrogen. An application of nitrogen @ 150 kg ha\(^{-1}\) and 75 kg ha\(^{-1}\) gave the highest bulb yield of 127.88 and 114.66 q ha\(^{-1}\), respectively. Likewise, Hassan and Ayoub (1978) also noted that increasing level of nitrogen gave highly significant increase in total yield as well as average bulb size of onion.

Feigin et al. (1979) observed that the onion crop received nitrogen @ 180 kg ha\(^{-1}\) of which, 22 per cent was applied as a basal dressing and remaining as a top dressing gave better yield of 63.71 t ha\(^{-1}\) and also improved bulb diameter, dry matter content and NPK uptake as compared to 90 and 170 kg N ha\(^{-1}\).

Maurya and Bhuyan (1982) reported that the maximum dry weight and diameter of bulb per plant were recorded under 150 kg N ha\(^{-1}\). The effect of nitrogen on dry weight and diameter of bulb was found to be linear upto 150 kg N ha\(^{-1}\) and the total yield of bulb was highly affected by nitrogen levels upto 150 kg ha\(^{-1}\) which produced the maximum yield of 8.19 t ha\(^{-1}\).

Villagran and Escaff (1982) studied the transplanted onion seedlings at different density and fertilized with nitrogen @ 0, 30, 60, 90 and 120 kg N ha\(^{-1}\) and observed that marketable yield was increased linearly with increase in nitrogen.
Saimbhi and Randhawa (1983) reported that the level of nitrogen significantly increased the bulb weight and yield over control in onion cv. Punjab-48.

Patil et al. (1983) conducted an experiment on black vertisol at Parbhani during rabi season and observed that the yield of onion was increased significantly from the plot receiving nitrogen to 311.2 q ha\(^{-1}\) by application of 150 kg N ha\(^{-1}\). Similarly, Nelson (1983) concluded that the yield and bulb size were improved by increasing the nitrogen rate.

Das et al. (1985) reported that an application of nitrogen stimulated the bulb growth as well as yield of garlic. The highest level of nitrogen gave the highest yield of garlic bulbs.

Patil et al. (1984) concluded that the largest bulb diameter (6.344 cm) was recorded under higher rate of nitrogen (150 kg N ha\(^{-1}\)).

Muzika (1986) observed the best performance with an application of N : P\(_2\)O\(_5\) : K\(_2\)O @ 120 : 90 : 90 kg ha\(^{-1}\) for increasing yield of one year crop.

Mohamedali and Nouri (1988) conducted an experiment over 3 seasons on onion cv. Nasi and they found that the nitrogen application increased seed yield in two out of three seasons.

Asiegbu (1989) studied in Nigeria and found that the highest bulb yield was obtained with 100 kg N ha\(^{-1}\) whereas an application of 200 kg N ha\(^{-1}\) and above resulted in yield reduction.

Patel and Patel (1990) studied the effect of application of nitrogen @ 0, 30, 60, 90 or 120 kg ha\(^{-1}\) and phosphorus @ 0, 30 or 60 kg ha\(^{-1}\) on yield of onion cv. Pusa Red and found that the nitrogen rate
had significant effect on bulb yield wherein, yield was increased with increase in nitrogen application up to 90 kg ha\(^{-1}\).

Pandey and Ekpo (1991) reported the highest bulb yield (460.2 q ha\(^{-1}\)), average bulb weight (197.8 gm) and total yield (31.1 \%) were with 120 kg N ha\(^{-1}\).

Singh and Sharma (1991) studied an application of four nitrogen rates (0, 40, 80 and 120 kg ha\(^{-1}\)) to onion cv. Pusa Madhuri seedlings and \(\text{P}_{2}\text{O}_{5}\) and \(\text{K}_{2}\text{O}\) both @ 50 kg ha\(^{-1}\) at the time of transplanting and found that the bulb diameter, dry weight and yield were increased with nitrogen application up to 80 kg ha\(^{-1}\). Similarly, onion cv. Boda Dura fertilized with nitrogen @ 120 kg ha\(^{-1}\) as top dressing gave the average total yield ranging from 34.57 t ha\(^{-1}\) to 36.79 t ha\(^{-1}\) (Sakashita et al., 1991).

Baloch et al. (1991) found that the highest bulb yield was obtained with application 125 kg N + 75 kg K\(_2\text{O}\).

Bhardwaj et al. (1991) conducted an experiment during the winter season at Solan (H. P.) on onion cv. Nasik Red in sandy clay loam soil and they found that an application of 80 kg N ha\(^{-1}\) and 60 kg P\(_2\text{O}_{5}\) ha\(^{-1}\) increased the size of umbel and seed yield per plant. Similarly, Herison et al. (1993) reported that the highest nitrogen level (225 ppm) produced the largest seedling and ultimately the largest bulb at harvest.

Ilin (1994) concluded that an application of nitrogen @ 80 and 120 kg ha\(^{-1}\) increased yield by 13 and 17 per cent as compared with no fertilizer application.
Warade et al. (1995) concluded that the highest onion yield was obtained by application of mineral fertilizer @ 75 : 50 : 50 NPK kg ha⁻¹.

Singh et al. (1997) recorded the highest gross and marketable yield (293.3 and 278.8 q ha⁻¹) with an application of 100 kg N + 25 kg P + 25 kg K ha⁻¹.

Vachhani and Patel (1996) carried out a field experiment at Navsari to study the effect of nitrogen @ 50, 100 or 150 kg ha⁻¹; P @ 25, 50 or 75 kg P₂O₅ ha⁻¹ and K @ 50, 100 or 150 kg K₂O ha⁻¹. The results revealed that the weight of bulb and yield were the highest with 150 kg N ha⁻¹, however it was at par with 100 kg N ha⁻¹.

Osinka and Kolota (1998) observed that the pre-planting nitrogen application had no significant effect on yield, however, applying Ekolist particularly at the lower rate increased yield.

2.4 Uptake studies

Kremer et al. (1979) studied the onion cv. Ori on sandy loam soil in Southern Arava where plants were supplied with 0, 90, 180, 220 or 300 kg N ha⁻¹ wherein, lower rates of nitrogen were inadequate and higher rates showed no advantages. The highest N uptake (2-2.7 kg ha⁻¹ per day) occurred at 90-150 days after sowing.

Mohmedali and Nouri (1988) observed that the nitrogen application resulted in a high total nitrogen content in the leaves.

Asiegbu (1989) observed that nitrogen application increased N concentration and N uptake in the bulb was generally the lowest and was generally the highest when lime was used at 1.5 t ha⁻¹.
Suojala et al. (1998) found that an increasing application of NPK rate, N uptake increased markedly. The foliage N content was low evidently as a result of late harvesting.

2.5 Economics

Rana et al. (1985) conducted an experiment on cv. Hisar fertilized with 3 nitrogen levels (50, 100 and 150 kg ha⁻¹) and recorded the maximum net profit by an application of 100 kg N ha⁻¹.

Singh et al. (1997) concluded that an application of FYM combined with 100 kg N + 25 kg P₂O₅ 85 kg K₂O ha⁻¹ gave the highest net returns of 32651 Rs. ha⁻¹.