REVIEW PAPER

Review on effect of Nitrogen and Phosphorous application on seed yield and nutrient uptake of onion (*Allium cepa* L.)

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ABSTRACT

Onion is a herbaceous biennial monocot cultivated as an annual crop. The number of flowers opening on each day was influenced by hours of sunlight and concentration of phosphorous (P) and nitrogen (N). N and P treatments tended to lower bolting percentages. The yield of onion seed per plant increased as the nitrogen in the nutrient solution increased where seed stalks were produced. The effect of early dressings of N on crops grown under conditions when nights are becoming cooler is shown to allow the plants to reach to flowering stage early in the growing season. There is maximum response of onions to P fertilization in the range 0-52 kg ha-1. Plant roots take up nitrogen from the soil solution principally as nitrates (NO_3^-) and NH_4^+ ions. Nitrate is the preferred form for uptake by most of the most plants. It is usually the most abundant form that can be taken up in well-aerated soils. Nitrogen fertilizer application improves phosphorus uptake from the soil.

Key words: Nitrogen, phosphorus, onion, plant.

1. INTRODUCTION

In recent times, there are about 750 species of the genus *Allium*. Japanese bunching onion, leeks and garlic are the most important edible *Allium* crops [1]. Onion (*Allium cepa*) is believed to have originated in Afghanistan, the area of Tajikistan and Uzbekistan, western Tien Shan and India while Western Asia and the areas around the Mediterranean Sea are secondary centres of development. *Allium cepa* is a herbaceous biennial monocot plant, cultivated annually. *Allium cepa* is used primarily as flavouring agents and its distinctive pungency, which is due to the presence of volatile oil (alkyl propyl disulphide). The mature bulb contains some amount of starch, appreciable quantities of sugars, proteins, and some vitamins like A, B, and C [2]. The total estimated area for onion production in Ethiopia is about 13,000 hectares, which produced 163,800 tonnes of onion in 2004 E.C with an average yield of about 12.9

t/ha. Onion seeds are highly perishable and poor in maintaining quality which loses viability within a year. One of the major problems for onion production is the lack of availability of good quality and high germination in the tropics is the lack of seeds [3]. At first, as an annual method it takes less than a year and doesn't involve lifting and storing the bulbs [4]. Enormous differences in average seed yields are observed depending on genotype, locality, season, soil type and method of seed production [4-5]. The expensive bulb seed are commonly used for seed production with medium size (4-5 cm diameter) are recommended for seed production [6]. The farmers mostly depend upon the imported seeds as domestic supply are not fulfilled as per the demand. Also the mostly germination is of poor quality with uniformity and susceptible to diseases [7].

In Ethiopia, 90-135 kg P_2O_5/ha and 81-144 kg N/ha urea is generally used for bulb production in sandy loam soil whereas 92 kg N/ha is used for seed production [8]. An adequate supply of nitrogen stimulates root growth and development as well as the uptake of other nutrients [9]. Plants respond quickly to the increased availability of nitrogen, as it increases the plumpness of cereal grains, the protein content of both seeds and foliage [10].

The nitrogen and phosphorous is an essential organic component of plant, often called the energy currency of the living cell: adenosine triphosphate (ATP). Synthesized through both respiration and photosynthesis, ATP contains a high-energy phosphate group that drives most energy-requiring biochemical processes. For example, the uptake of nutrients and their transport within the plant, as well as their assimilation into different bio-molecules are energy-using plant processes that require ATP [10].

In most plant species, the total phosphorus content of healthy leaf tissue is not high, usually comprising only 0.2 and 0.4% of the dry matter [9]. For root growth particularly the development of lateral roots and fibrous roots is encouraged by phosphorus.

Species of *Allium* are readily colonized and the host root is greatly influenced by many factors like chemical and physical environment of the plant. The chemical factors are the concentration of phosphorus in the soil which has the most marked and well-documented effects.

2. Seed Production Potential of *Allium*

The bulb, flower and seed production of *Allium* are controlled by a climatic condition such as temperature and photoperiods. The seed production is more demanding than bulb production [11]. Temperature greatly influences the flowering of *Allium*. Cool temperature with adequate water supply is most suitable for earlier growth followed by warm, drier condition for maturation. Low temperature (9-17°C) is required for flower stalk development [12].

As stated by Prats *et al*. (2007) [13] and Sidhu *et al*. (2006) [14], umbel diameter was the primary determining factor for seed yield. It indicated that the higher seed yield in onion cultivars was due to the higher number of seed stalks per plant. To a wider umbel diameter which was influenced by the application of N and P fertilizers. Generally, increasing application rates of N fertilizer increased the seed yield per plant [14]. It was observed that seed yield increased linearly from 830 to 1100 kg/ha by increasing N at the rate of 0 to 150 kg/ha. Nwadukwe and Chude (1995) [15] have reported that N rate at 50 or 100 kg/ha with P at 50 kg/ha increased seed yield from 184kg/ha to 226 kg/ha.

3. Flower Development and Seed Formation

Phosphorus is one of the mobile macro elements which is of great use for plants especially at reproductive stages [14]. One of the most important parts of phosphorus is its aid in root growth and influences the vigour of the plant. In is observed in various studies that P and N are one of the most important elements in growth, flowering as well as final seed yield of plant. The exposure of N of the plant lead to the increment in stalk heights for other cultivars of onion are in the range of 76-93 cm. The N contributing to the higher rates of vegetative growth and stem elongation when high doses of nitrogen fertilizers are applied to the plants [17].

Patil *et al*. (2003) [18] recorded that total Flowering days ranges from 82.5-88.3 days under different moisture regimes. An increase in the release of P from vacuoles can initiate the respiratory burst which correlated with fruit ripening [19-21]. The effect of phosphorus application in increasing bulb yield and its characteristics could be explained through the role of phosphorus [12].

3.1. Components of Seed Yield of onion

The number of flower stalks per plant varied from 1 to 15 per plant at Melkassa and the terminal number of 50-200 flowers produced per umbel on Adama Red depending on the number of shoots axis [4].

The study of Ogawa in 2006 [22] indicated that plants with the longest seed stalks produced the highest seed yield and seed weight was considered an estimation of vigour. Similarly, in India, an investigation on 40 onion was conducted where the cultivars tried to correlate seed yielding capacity with important plant characters [12].

The cultivars with bigger bulbs produced wider inflorescences and greater seed yield. The variation in yield among the cultivars was caused by the large difference in the number of umbels per plant and the number of productive florets per umbel [13].

Sidhu *et al.* (2006) [14] reported that the higher seed yield in some onion cultivars was due to the higher number of seed stalks per plant and to a broader umbel diameter. Hence, the capacity of the plant to flower was expressed by the umbel size.

3.2. Effect of Nitrogen and Phosphorous on Onion Production

According to Ahmed (2008) [23], the fertilizer N, P and K affect bolting, the yield and quality of onion seed. N and P treatments tended to lower bolting percentages, while application of K tended to encourage bolting (7-23 % increases) of onion cultivar. However, other work by Hassan (2005) [24], which included irrigation timing and nitrogen as the factors studied, indicate that both bolting and doubling were increased at the higher N level.

On the contrary, the effect of N nutrition on the number of inflorescences plant and their development did not show any significant response on bolting. But under low-temperature induction, floral bud formation was enhanced by low N levels as compared with high N regime [11]. In another study, the plant was grown in green house, and resulted that the plant which was given little or no nitrogen were small and seldom divided to form more than one seed-stalk but bolted uniformly. Plants on high nitrogen, however, were strongly vegetative and frequently bulbed instead of bolting. It was further indicated that the yield of seed per plant increased as the nitrogen in the nutrient solution increased where seed stalks were produced. According to Ahmed (2008) [23] fertilizer N, P and K affect the yield and quality of onion seed product how other studies showed that a higher level of nitrogen increased seed yield but at the expense of seed quality. High K levels during bulb production were carried over to the second year and also enhanced seed quality.

Mohamedali and Nourai (2004)[25] stated that the application of nitrogen fertilizer appreciably increased seed yield per onion and umbel number per plant. The application of N and P for two consecutive seasons, significantly increased plant height, flower stalk thickness and seed yield. However, a highly significant increase in seed yield was obtained when P was used in combination with N. They separately or in combination proved to have no effect on the number of branches or flower stalks produced per plant.

Earlier evidence points that N starvation during the early growth stage encourages bolting in the first growing season. The effect of early dressing of N on crops grown under colder conditions allows the plants to reach a ‘bolting inducible’ stage [26]. In Italy the N fertilizer levels from 0 to 150 kg ha-1 in 30 kg ha-1 increments proved that seed yield increased linearly from 830 to 1100 kg ha-1 with increasing N [27].

The observation on N and P fertilizer trial on onion in a semiarid tropical soil of Nigeria resulted in increased number of umbels per original bulb, seed weight per umbel with seed yield. The application of P at 50 kg ha-1, gave significantly higher seed yield than other N and P rate combinations tested [16]. Application of both P and K together with N didn't affect the number of inflorescences formed. However, applications of either P or K significantly enhance bolting [11]

3.2.1. Effect of N and P on days to bolting, flowering and maturity of onion

Nitrogen has physiological functions in the plant which increase the plumpness and succulence of crops, thereby encourages the vegetative growth rather than reproductive structure development [28]. Furthermore, the relatively cool climatic condition of the experimental site compared with Melkassa seemed to have contributed to delaying the overall growth of the crop [16].

The nutrients absorbed from the soil could have diverted and sink into vegetative parts for photosynthesis and resulted in plants. The duration of flowering was expected to be affected by the growing condition [4].

Patil *et al*. (2003) [18] recorded days of flowering ranging from 82-88 days under different moisture regimes. It is the effect on the reduction of sugar concentration in the leaves during the early ripening stage and inhibition of the translocation of assimilated products [21].

Sidhu *et al*. (2006) [14] found stalk heights for other cultivars of onion in the range of 76-93 cm. This increment of height after the application of N could be due to the major factor to the higher rates of vegetative growth and stem elongation when high doses of nitrogen fertilizers are applied to the plants.

The use of N in the environment and the size of the mother plant also have a modifying effect on the flower, stalk height and diameter [5]. On the other hand, phosphorus fertilizer application didn't show significant difference both on flower stalk height and diameter. This might be due to non-availability to the plant at the rate sufficient for increasing the flower stalk height. The diameter is increased by P application probably due to the fact that this element was vital for flowering, seed formation and related reproductive activities [9].

3.2.2. Effect of P and N fertilizer on seed yield of onion

Cuocolo and Berbieri (2006) [27] reported that increasing application rates of N fertilizer increased the seed yield per plant. The effect of phosphorus application in increasing bulb yield and its characteristics could be explained through the role of phosphorus [12]

The highest rates of P 115 and 147 kg ha−1 give better growth and yield [29]. Growers on the southeast Georgia use a considerable amount of Phosphorus fertilizer as high as 89 kgha−1 based on a standard fertilizer program. Significant amounts of Phosphorus fertilizer, particularly $(NH_4)2H_2PO_4$, usually appear greener with larger tops. High Phosphorus fertilizer may be warranted when onion tops are damaged. These onions may also benefit from high P fertilizer in which large green tops are important. In addition, P has an indispensable role in energy metabolism, high energy of hydrolysis of P and various organic phosphate bonds being used to induce chemical reaction [26].

There is maximum response of P fertilization to onions in the range 0-52 kg ha-1. Depending on yield levels, P uptake rates in onion are estimated to be about 15-30 kg ha-1. Depending on soil P status, cultivar and plant density, P application rates of up to 200 kg ha-1 were found to maximize onion yields and bulb weights and reduce storage loss of bulbs [12]. Increased P level also improve bulb size and the number of marketable bulbs in onion. Regardless of the P status of the soil, placement of P fertilizers in the soil near the plant would be the most effective method of Phosphorus supply to onion plants [4].

3.3. Availability and uptake of nitrogen on onion

Plant roots take up nitrogen from the soil solution principally as nitrates (NO^{3-}) and NH^{4+} ions. Although certain plants grow best when provided mainly one or the other forms, a relatively equal mixture of the two ions gives the best results with onion. The quantities of NO^{3-} found in the soil however, usually represent only enough N to support uptake for a short period. N anions move easily to the root of onion with the flow of soil water and exchange at the root surface with HCO^{3-} or OH- ions that, in turn, stimulate an increase in the pH of the soil solution immediately around the root. In contrast, ammonium cations exchange at the root surface with hydrogen ions, thereby lowering the pH of the solution around the roots. The effects of these two ions (HCO^{3-}or OH) on the pH of the root environment are known to influence the uptake of other companion ions, such as phosphates [30].

Ammonium in the soil solution is susceptible to uptake by roots and is in equilibrium with a much larger quantity of exchangeable NH^{4+}. The exchangeable NH^{4+} often equilibrates with non-exchangeable NH^{4+} which is not rapidly displaced by neutral salt solutions. Concentrations of NH^{4+} in the soil solution usually are low enough that relatively little movement occurs with flows of water. Both ammonium (NH4+) ion is held to cation exchange sites and resists leaching. However, Nitrate (NO^{3}) is the most readily leached form of nitrogen [6]

3.4. Total nitrogen concentration in soil

The response of crops to fertilizer, which is a function of nutrient uptake, is highly variable and depends on the crop, type of soil, past use of the land, local weather condition as well as the choices of the whole season.

Nitrogen fertilizer application improves phosphorus uptake from the soil [28]. At a low level of N availability uptake and tissue concentration of N become low, and the yield is proportional to N uptake in grain [31]. This increment of whole plant uptake of N by N and P fertilization and their interaction might be due to the fact that nitrogen and phosphorus fertilizer application increase P and N uptake from the soil [31].

In soil with high P, there was a direct correlation between the N and P uptake of other crops [14, 19, 28]. The increasing N and P uptake with increasing N and P fertilizer levels in the soil as a result of improved availability and uptake through increased root growth and effective absorption. The plant uptake of nutrients followed a similar pattern as the leaves and seeds; because the plant uptake was the sum of the two.

3.5. Availability and uptake of phosphorus on onion

As we know that onions absorb P in the form of $H_2PO_4^-$. But the physical and chemical properties of soil were reported to influence the solubility of P and its absorption reactions in soils. These include the nature and amount of the soil minerals, soil pH, cation and anion effect, extent of P saturation, response time, temperature, flooding and fertilizer management [29].

The energy stored in P compounds allows transportation of nutrient across the cell wall and the synthesis of nucleic acid and proteins. The addition of P fertilizer ensures that crops will reach their full potential by using additional amount, by promoting resistances to root diseases [9].

3.6. Total Phosphorous Concentration in Soil

Too much P level affects plant growth by suppressing the uptake of iron, potassium, zinc. It potentially causes deficiency symptoms of these nutrients to create the occurrence of deficiency in plants. Any chemical fertilizers that have P like diammonium phosphate (DAP) will fix phosphorus deficiency [13].

Both inorganic and organic forms of P occur in soils, and both are important to plants as sources of this element. The relative amounts in the two forms vary greatly from soil to soil. The organic fraction generally constitutes 20-80% of the total phosphorus in surface soil horizons. The deeper layer may hold large amounts of inorganic phosphorus, especially in soils from arid and semiarid regions [9].

P by far is found to be in the smallest quantities or in readily soluble forms in mineral soils compared with all other macronutrients found in soils, generally ranging from 0.001 mg/L in rich, heavily fertilized soils. The chemical species of P present in the soil solution is determined by the solution pH [32]. In strongly acid soils (pH 4.0 to 5.5), the monovalent anion $H_2PO_4^-$ is dominated and is slightly more available to plants than the divalent anion HPO_4^{-2} which characterize alkaline solutions.

Brady and Weil (2002) [9], reported that two phenomena tend to control the concentration of P in the soil solution and its movement in soils. These are the solubility of phosphorus-containing minerals and the fixation or adsorption of P ions on the surface of soil particles in unavailable (insoluble) forms. Dissolved phosphate ions in mineral soils are subject to many types of reactions that tend to remove the ions from the soil solution and produce phosphorus-containing compounds of very low solubility. The tendency for soils to fix phosphorus in relatively insoluble forms has far-reaching consequences for phosphorus management.

The availability of inorganic phosphorus is largely determined by soil pH, soluble iron, aluminium and manganese and calcium minerals amount of decomposition of organic matter, and activities of microorganisms [32].

Since soil pH drastically influences the reaction of P with the different ions and minerals. Phosphorus unavailability is not only due to the tendency of soil to fix the added phosphorus but also by the slow rate of element movement into the plant root. P is essentially an immobile nutrient, and continued application of phosphate fertilizers tends to increase its level. Particularly it's level in the liable forms that can release phosphorus to the soil solution [9].

Control that can be exerted over P availability seems to be associated with liming, fertilizer placement and organic matter maintenance. By holding the 6-7 pH of the soil, the P fixation can be kept at a minimum pH [32]. Due to the general immobility of P in the soil profile, fertilizer placement is generally more critical for P than N. Phosphate fertilizers are commonly placed in localized bands to prevent rapid reaction with the soil [32].

4. RECOMMENDATION

Despite an enormous potential to produce onion bulbs, many production constraints of onion were observed before so to solve these problems; the following points should be considered.

- To increase the yield of onion seed, the optimum application of N and P fertilizer should be determined.
- Research should be repeated and should be done at a different location to determine the optimum N and P fertilizers application to obtain good yields of onion.
- The researcher should be given attention for the optimum use of N and P fertilizer according to soil and climatic conditions.

5. CONCLUSION

The use of fertilizer practices for the production of onion seed crop can be used widely. Abundant supply of N stimulates growth and development as well as the uptake of other nutrients. Fertilizer N and P affect bolting and the yield and quality of onion seed. However, they were strongly vegetative and frequently bulbed. Nitrogen and phosphorus separately or in combination proved to have no effect on the number of branches or flower stalks produced per plant. The delay in maturity due to N fertilizer application could be possibly due to the fact that this element affects the supply of carbohydrate during the critical period of the reproductive phase. The use of these fertilizers can definitely help the cultivars. This will help both the consumer as well as cultivars with quality and economic benefits.

6. CONFLICT OF INTEREST

No conflict of interest

7. SOURCE/S OF FUNDING

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