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Review on Effects of Nitrogen and Phosphorus Fertilizers on Seed Yield of Onion (Allium cepa L.)

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ABSTRACT

Onion is an herbaceous biennial monocot cultivated as an annual. In recent estimations, there are about 750 species in the genus Allium, among which onion, Japanese bunching onion, leeks and garlic are the most important edible Allium crops. The higher seed yield in onion cultivars was due to the higher number of seed stalks per plant and to a wider umbel diameter which were influenced by application of N and P fertilizers. The number of flower opening on each day was influenced by the number of hours of sunshine and concentration of phosphorous and nitrogen. N and P treatments tended to lower bolting percentages. The yield of seed per plant increased as the nitrogen in the nutrient solution increased where seed stalks were produced. The early flowering by the application of P fertilizer was due to fact that phosphorus involvement in metabolic and physiological activities. The highest rates of Phosphorus 115 and 147 $kgha^{-1}$ gives better growth and yield. There is maximum response of onions to Phosphorus 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 of N for uptake by most plants, and 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. Onion absorb phosphorous in the form of $H_2PO_4^-$ and $H_2PO_4^-$. Too much phosphorus level affects plant growth by suppressing the uptake of iron, potassium and Zink.

The availability of inorganic phosphorus is largely determined by soil pH. Leaching losses of nitrate are growing crop cover to absorb the nitrates as rapidly as they are produced. Soil pH drastically influences the reaction of phosphorus with the different ions and minerals. To increase the yield of onion, seed the application of N and P fertilizer should be determining.

Key Word: Fertilizer Rates, Onion, Seed.

INTRODUCTION

1.1. Background and Justification

Onion (*Allium cepa* L.) known as the bulb onion and it is the most widely cultivated species of the genus Allium, and belongs to the family Alliaceae. Onion is also one of the most important monocotyledonous, cross-pollinated and cool season bulb vegetable crops produced throughout the worldOnion is widely used as a condiment to enhance the flavor of food. Almost all spicy dishes contain onion as one of the important ingredient used for culinary purposes. People consider it as an indispensable part of human diet. It is a rich source of several minerals and vitamins (Raemaekers, 2015).

Onion is also considerably important in the daily Ethiopian diet for the preparation of traditional foods. Some of the plant parts are edible, the bulbs and the lower section of stem are the most popular as a seasoning or a vegetable in stews (MoARD, 2013). Onion has also a long history of medicinal importance. Compounds from onion have been reported to have a range of health benefits which include anti carcinogenic properties, anti-platelet activity, antithrombotic activity, asthmatic and antibiotic effects and effective against the common cold, heart disease, diabetes, osteoporosis, and other diseases (Griffiths *et al.*, 2014). Onions can be grown under a wide range of climatic conditions. However, their production is more successful under mild climate without extremes of heat or cold and excessive rainfall (Lemma, 2011). Ethiopia's diversified agro-climatic conditions suitable for the production of a broad range of fruits, vegetables and flowers also allow successful production of onion (Lemma *et al.*, 2016).

Currently, onion is an important cash crop for Ethiopian farmers hence the crop is produced in different parts of the country for local consumption and for regional export market (MoARD, 2013). However, the best growing altitude for onions under Ethiopian condition is between 700 and 1800 m above sea level.

There are two onion seed production methods, the seed-to-seed and bulb-to-seed methods. The latter method allows rouging and selection to include mature bulb morphology and is especially important for basic seed production. The first, as an annual method takes less than a year and doesn't involve lifting and storing the bulbs (Brewster, 2013; George, 2015). Enormous differences in average seed yields are observed depending on genotype, locality, season, soil type and method of seed production (Jones, 2010.)

Nutrients play a significant role in improving productivity and quality of vegetable crops. Onions are the most susceptible crop plants in extracting nutrients, especially the immobile types, because of their shallow and unbranched root system; hence they require and often respond well to addition of fertilizers (Rizk *et al.*, 2013). Therefore, optimum fertilizer application and cultivation of suitable varieties with appropriate agronomic practices in specific environment are necessary for obtaining good yield of onion. Nitrogen (N) and phosphorus (P) are often referred to as the primary macronutrients because of the probability of plants being deficient in these nutrients and the large quantities taken up from the soil relative to other essential nutrients (Marschner, 2015). Nitrogen plays an important role for optimum yield of onion and is found to be essential to increase the bulb size and yield. Increasing nitrogen application rates significantly enhances plant height, number of green leaves per plant and weight of bulb, marketable yield and also total soluble solids (Nasreen *et al.*, 2007; Al-Fraihat, 2009)

1.2 Objective of the Review

- To review the effects of N and P fertilizer application on seed yield of onion.

2. LITERATURE REVIEW

2.1. Botany and Origin

Onion (*Allium cepa* L.*)* belongs to the family Alliaceae and the genus Allium. The genus contains of about 750 species, among which onion, Japanese bunching onion, leeks and garlic are the most important once (Robinowitch and Currah, 2002). Onion is herbaceous biennial monocot but cultivated as an annual crop for bulb production. For seed production onion is cultivated as biennial crop, in the first season bulbs are formed while flower stalks and seeds are developed in the second season (Lemma, 2011). The onion bulb consists of the thickened bases of leaves attached to a small conical stem. The bulb varies from flat to round in shape. Leaves are long, round and hollow. Flowers are small in size and formed at terminal tip of the stems as umbels (Norman, 2011). The primary center of origin of onion is Central Asia with secondary center in Middle East and Mediterranean Region (Zohary and Hopf, 2006).

2.2. Distribution and Importance of Onion

Onions are one of the most ancient vegetable crops under cultivation. Onion has been widely distributed to various countries of the world. Onion is probably cultivated in almost all countries of the tropical Africa including Ethiopia (Grubben and Denton, 2014). In Ethiopia, onion is relatively a recent introduction. It introduced to the agricultural community in the early 1970s through foreigners. However, it rapidly becomes a popular vegetable crop widely grown in the country (MoARD, 2031).

Onion is by far the most important of all bulb crops cultivated commercially in most parts of the world primarily used as flavoring agent in preparing various dishes. Its distinctive pungency is due to the presence of a volatile oil (allyl propyl di-sulphide) (Malik, 2016). The matured bulb contains some starch, appreciable quantities of sugars, some protein, and vitamins A, B, and C and minerals.

Moreover, onion has medicinal importance because of its anti carcenogenic, and antibiotic properties and anti-platelet, antithrombotic activities (Griffiths *et al.*, 2017).

Onion is one the most important cash crops produced by small scale farmers that helps the farmers to increase their income and thus to improve their livelihood (Lemma and Shimelis, 2013).

2.3 Production and productivity of onion in Ethiopia

The production and productivity of onion in Ethiopia is estimated to be about 230,745.2 tons and 10.1t/ha, respectively. In the same production season about 705,877 households were participated in the production of onion CSA (2018). Onion is one the most important cash crops produced by small scale farmers that helps the farmers to increase their income and thus to improve their livelihood (Lemma and Shimelis, 2015). According to CSA, (2018) the average annual production of onion is about 230,745.2 tons produced on 24, 375.7 hectares of land. About 705, 877 households are participated in the production of onion in the country.

The production and productivity of vegetables in general and onion in Ethiopia is very low compared to the potentials the country has. Their production is facing various problems which contribute to this low level of production and productivity. Among various constraints lack of appropriate agronomic packages, shortage of seeds of improved varieties, diseases, insect pests and poor extension services, high costs of chemical fertilizers and sometimes unavailable to small scale farmers (Melkamu *et al.,* 2015). Generally, increasing application rates of N fertilizer increased the seed yield per plant seed yield increased linearly from 830 to 1100 kg/ha with increasing N at the rate of 0 to 150 kg/ha in 30 kg/ha increments. N rate at 50 or 100 kg/ha with P at 50 kg/ha increased seed yield from 184kg/ha to 226 kg/ha compared to the control treatment Bulbing, flowering and seed production of onion are controlled by climatic condition such as temperature and photoperiod and seed production is more demanding than bulb production (Rabinowitch, 2010).

Temperature greatly influences the flowering of onion. Cool temperature with adequate water supply is most suitable for earlier growth followed by warm, drier condition for maturation. Low temperature (9-17 ^{o}C) is required for flower stalk development (Singh, 2011).

2.3.1. Flower development and seed formation

Phosphorus is one of the mobile macro elements which do lots of things for plants. One of the most important parts of phosphorus is its aid in root growth and influences the vigorosity of the plant and it is one of the most important elements in growth, flowering as well as final seed yield of plant. It is the major important nutrient in the plants reproductive stages (Sidhu *et. al.* 2016) found that stalk heights for other cultivar of onion in the range of 76-93 cm, this increment of height by applied N in part could be due to major factor of N contributing to the higher rates of vegetative growth and stem elongation when high doses of nitrogen fertilizers are applied to the plants (Marschner, 2015; Gupta and Sharma, 2010). Patil *et al.* (2013) reported that days to flowering ranging from 82.5-88.3 days under different moisture regimes. The early flowering of onion by the application of P fertilizer could be due to fact that phosphorus involvement in metabolic and physiological activities i.e., an increase in the release of P from vacuoles can initiate the respiratory burst which correlated with fruit ripening, Woodrow and Rowan, (2016) reported that, the flowering period lasted 29 days and during the middle 15 days, 84.9% of the total flowers were open. The number of flower opening on each day was influenced by the number of hours of sunshine and concentration of phosphorous and nitrogen. The effect of phosphorus application in increasing bulb yield and its characteristics could be explained through the role of phosphorus (Singh *et al*, 2010).

2.3.2. 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 (Lemma, 2013).

The study of Lemma, (2013) indicated that plants with the longest seed stalks produced the highest seed yield and seed weight was considered an estimation of vigor. Similarly, in India, an investigation on 40 onion cultivars tried to correlate seed yielding capacity with important plant characters. They found that seed yield per plant was positively and significantly correlated with the number of seed stalk per plant and seed yield per umbel Ogawa in 2011.

This indicated that this character could be a good index for seed yield estimation in onion. 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 number of umbels per plant and number of productive florets per umbel (Prats *et al*., 2016). Sidhu *et al*. (2016) also reported that the higher seed yield in some onion cultivars was due to the higher number of seed stalks per plant and to a wider umbel diameter and, hence, the capacity of flowering of the plants was expressed by the umbel size.

2.4. Effect of Fertilization on Onion Seed Production

According to Ahmed, 2012 reported that fertilizer N, P and K affect bolting and 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 Nasi grown on heavy clay soil in Sudan. However, other work by Hassan (2014), 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, effect of N nutrition on the number of inflorescences per 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 (Rabinowitch and Brewster, 2010). In Maryland, using yellow Bermuda 986' in green house, showed that the plant which were given little or no nitrogen were small and seldom divided to form more than one seed-stalk, but they bolted uniformly. Plants on high nitrogen, however, were strongly vegetative and frequently bulbed instead of bolting. He further indicated that the yield of seed per plant increased as the nitrogen in the nutrient solution increased where seed stalks were produced.

Fertilizer N, P and K affect the yield and quality of onion seed product. How other studies showed that 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 (Ahmed 2012).

2.5. Main and Interaction Effects of Applied N and P Rates

2.5.1. Days to bolting, flowering and maturity

Shemelis (2010) in his study of flower and seed production potential of onions in Melkasa, found that Adama Red was bolted within 24 days. Nitrogen has physiological functions in plant which increase the plumpness and succulence of crops there by encourages the vegetative growth rather than reproductive structure development. Furthermore, the relatively cool climatic condition of the experimental site compared with Melkassa seemed to have contributed for delaying the overall growth of the crop (Aster,2016).

The nutrients absorbed from the soil could have diverted and sink into vegetative parts for photosynthesis and resulted in plants will end up with a luxurious foliage growth. The duration of flowering was expected to be affected by the growing condition (Globerson *et. al.*, 2011).

Patil *et al.* (2013) recorded days to flowering ranging from 82.5-88.3 days under different moisture regimes. The early flowering by the application of P fertilizer was due to the fact that phosphorus involvement in metabolic and physiological activities i.e., an increase in the release of P from vacuoles can initiate the respiratory burst which correlated with fruit ripening.

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 reproductive phase through its effect on the reduction of sugar concentration in the leaves during the early ripening stage and inhibition of the translocation of assimilated products (Marschner, 2015).

Sidhu *et al.* (2016) found stalk heights for different cultivars of onion in the range of 76-93 cm. This increment of height applied N in part could be due to major factor of N contributing to the higher rates of vegetative growth and stem elongation when high doses of nitrogen fertilizers are applied to the plants.

2.5.2. Effects P and N on seed yield of onion

Cuocolo and Berbieri (2018) 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 (Singh *et al*, 2010). The highest application of phosphorus (92kg/ha phosphorus) fertilizer had a major effect on the productivity of onion plant, hence increased total bulb yield and its components. Application of phosphorus level positively increase and significantly affect bulb length, bulb diameter, average bulb weight, bulb dry matter content, marketable yield and total bulb yield (Shaheen *et al*. 2017).

The highest rates of Phosphorus 115 and 147 kg/ha graves better growth and yield (Singh and Singh, 2010). Growers on the south east Georgia use a considerable amount of Phosphorus fertilizer as high as 89 kg/ha based on a standard fertilizer program. Significant amounts of Phosphorus fertilizer, usually appear greener with larger tops. High Phosphorus fertilizer may be warranted when onion tops are damaged such as during hailstorms, these onions may also benefit from high Phosphorus fertilizer in which large green tops are important (Boyhan *et al*., 2011).

The advanced of Phosphorus application in increasing the tonnage bulbs yield and its physical properties could be explaining through the role of phosphorus which is extremely important as a structural part of many components, notably nucleic acid and phospholipids. In addition, phosphorus has an indispensable role in energy metabolism, high energy of hydrolysis of phosphate and various organic phosphate bonds being used to induce chemical reaction (Shaheen *et al*, 2017).

There is maximum response of onions to Phosphorus fertilization in the range 0-52kg/ha. Depending on yield levels, Phosphorus uptake rates in onion are estimated to be about 15-30 kg/ ha. Depending on soil Phosphorus status, cultivar and plant density, phosphorus application rates of up to 200 kg/ha were found to maximize onion yields and bulb weights (Patil *et al.*, 2013) and reduce storage loss of bulbs (Singh *et al*., 2010).

Increased Phosphorus levels are also known to improve bulb size and the number of marketable bulbs in onion. Regardless of the Phosphorus status of the soil, placement of Phosphorus fertilizers in the soil near to the plant would be the most effective method of Phosphorus supply to onion plants (Brewster, 2014).

2.6. Effect of N and P Concentration on Nutrient Uptake

2.6.1 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. Nitrate is the preferred form of N for uptake by most plants, and it usually is the most abundant form that can be taken up in well-aerated soils. The quantities of NO_3^-found in soil at any time, however, usually represents only enough N to support uptake for a short period. Nitrate 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 both ammoniums (NH_4^+) ion is held to cation exchange sites and resist leaching. However, Nitrate (NO_3) is the most readily leached form of nitrogen. Both ammonium (NH_4^+) ion is held to cation exchange sites and resist leaching. However, Nitrate (NO_3) is the most readily leached form of nitrogen (Brady and Weli 2012).

2.6.2. Total nitrogen concentration in soil

Response of crops to fertilizer, which is a function of nutrient uptake, is highly variable and depends on crop, type of soil, past use of the land, local weather condition as well as the choices of the whole season (FAO, 2016). Nitrogen fertilizer application improves phosphorus uptake from the soil (Chandler, 2015).

At low level of N availability uptake and tissue concentration of N become low and the yield is proportional to N uptake in grain. 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 (Borrell *et. al.*, 2016).

In a soil with high P, there was a direct correlation between the N and P uptake of other crops as reported by (Panda *et al.* 2015), reported that 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 similar pattern as the leaves and seeds; because the plant uptake was the sum of the two.

2.6.3. Availability and uptake of phosphorus on onion

Onion absorb phosphorous in the form of HPO_4^{2-} and $H_2PO_4^-$. The physical and chemical properties of soil were reported to influence the solubility of phosphorus and its absorption reactions in soils. These include the nature and amount of the soil minerals, soil pH, cation effect and anion effect, extent of phosphorus saturation, reaction time and temperature, flooding and fertilizer management (Tisdale *et al*, 2015). The addition of phosphorus fertilizer insures that crops will reach their full potential by using additional phosphorous, to encourage root growth and promoting resistances to root diseases (Brady and Weil, 2012).

2.6.4. Total phosphorous concentration in soil

Too much phosphorus level affects plant growth by suppressing the uptake of iron, potassium and Zink. Potentially causing deficiency symptoms of these nutrients to cause the occurrence of deficiency in plants.

Phosphorus has by far the smallest quantities in solution 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 phosphorus present in the soil solution is determined by the solution pH (Miller and Donhaue, 2015). In slightly more available to plants than the divalent anion HPO_4^{-2} which characterize alkaline solutions, strongly acid soils (pH 4.0 to 5.5), the monovalent anion $H_2PO_4^-$dominates.Brady and Weil

(2012), reported that two phenomena tend to control the concentration of phosphorus in the soil solution and the movement of phosphorus in soils. These are the solubility of phosphorus containing minerals and the fixation or adsorption of phosphorus ions on the surface of soil particles as plant 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, aluminum and manganese, presence of iron-, aluminum- and manganese-containing minerals, available calcium and calcium minerals amount of decomposition of organic matter, and activities of micro- organisms (Miller and Donhaue, 2015). Since soil pH drastically influences the reaction of phosphorus with the different ions and minerals. Phosphorus unavailability is due not only to the tendency of soil to fix the added phosphorus but also to the slow rate of movement of this element to plant root in the soils. Phosphorus is essentially an immobile nutrient and continued application of phosphate fertilizers tends in time to increase the levels of this nutrient in the soil and particularly its level in the liable forms that can release phosphorus to the soil solution Pierzynski and Logan 2013). By holding the pH of soils between 6 and 7, the phosphate fixation can be kept at a minimum (Miller and Donahue, 2015). 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 (Miller and Donahue, 2015).

3. SUMMARY AND CONCLUSIONS

Onion is grouped under the family of alliaceae. Onion seeds are well known to be highly perishable and poor in keeping quality and lose viability within a year. One of the problems of onion production is the improper application of N and P application for the true to type and of high germination and vigor. Fertilizer practices for the onion seed crop vary widely.

There are two onion seed production methods, the seed-to-seed and bulb-to-seed methods. A good supply of nitrogen stimulates root growth and development as well as the uptake of other nutrients. Plants responds quickly to increased availability of nitrogen, their leaves turning deep green in color. Root growth, particularly development of lateral roots and fibrous rootlets, is encouraged by phosphorus. Fertilizer N, P and K affect bolting and the yield and quality of onion seed. Plants on high nitrogen, however, were strongly vegetative and frequently bulbed instead of bolting. Nitrogen and phosphorus separately or in combination proved to have no effect on the number of branches or flower stalks produced per plant. High bolting levels in plant raised from seed have also been reported to result from using low level of N. The nutrients absorbed from the soil could have diverted and sink into vegetative parts for photosynthesis and resulted in plants will end up with a luxurious foliage growth. 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 reproductive phase. Increasing application rates of N fertilizer increased the seed yield per plant. Plant roots take up nitrogen from the soil solution principally as nitrates (NO_3^-) and NH_4^+ions. In order to optimize phosphorus and nitrogen availability through P and N addition, many factors should be considered. Because of the immobility of phosphorus in most soil, these factors are: timing and placement of phosphorus fertilizer, temperature of the soil, compaction, moisture, aeration, PH, type and amount of nutrient (including phosphorus) status of the soil. Soil test should be als considered for the availability of phosphorus and Nitrogen in the soil.

So optimum nitrogen and phosphorus fertilizers rates is recommending to enhance the production of seed yield of onion but further study in different areas and season is required for sound recommendation.

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