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Research Article

Optimization of NPK combination for seed production of onion (*Allium cepa*) crop

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Abstract

Low productivity along with extensive usage of onion may cause shortage of this crop, as our country is facing high population problem. Mainly, there are two causes of low yield, lack of improved production technologies and poor quality of seed. Moreover, nutrient management is also an important aspect for getting higher yield. The current trial was conducted in RCBD with three replications and eight treatments. Treatments included different NPK fertilizer combinations i.e. T_1: Control, T_2: 30-20-00, T_3: 60-40-15, T_4: 90-60-30, T_5: 120-80-45, T_6: 150-100-60, T_7: 180-120-75, T_8: 210-140-90 kg NPK ha^{-1} and three replications. Data on multiple parameters viz. time to sprouting (days), number of shoots (plant^{-1}), leaf length (cm), flowering stalk (plant^{-1}), stalk length (cm), number of flowers (umbel^{-1}), umbel diameter (cm), 1000-seed weight (g), seed yield (kg ha^{-1}) were collected and statistically analyzed. It was noticed that increment of fertilizer rates delayed sprouting but increased the number of shoots, leaf length, flowering stalks, length of flowering stalks, flowers (umbel^{-1}) and umbel diameter in onion cv. Shah Alam. Highest fertilizer dose (T_8:210-140-90 kg NPK ha^{-1}) showed its superiority by producing maximum shoots (6.48 plant^{-1}), longest leaves (41.20 cm), longest flowering stalk (67.10 cm), flowers (372.22 umbel^{-1}), umbel diameter (6.45 cm), seed weight (3.03 g) and seed yield (420.0 kg ha^{-1}). But almost all these parameters were statistically similar with T_7: 180-120-75 kg NPK ha^{-1}, hence, it is recommended that T7 and T8 should be used for getting maximum onion production.

Keywords: *Allium cepa*; Flowering stalk; NPK; Onion; Seed weight; Seed yield; Umbel

Introduction

Onion (*Allium cepa* L.) is one of the important vegetable crop of winter season which is used for consumption in raw and mature bulb stage [1]. It is considered the next most important vegetable after tomato among horticultural crops [2] and ranks first major exportation crop. People throughout the world appreciate it due to its distinctive flavor and medicinal properties [3, 4]. Onion has an essential role in our daily diet as it is commonly used in nearly all food arrangements for their unique flavor [5] or their ability to enhance food flavors [6]. Onion is also favored for its diuretic, stimulant and anti-bacterial properties. Using onion reduces lipid and blood cholesterol level, thus, preventing heart diseases [7]. Extensive use, as well as lower yield of onion may cause a shortage of this crop, as our country is facing high population problem. The two leading causes of low yield are lack of improved production technologies and secondly poor quality of seed. Onion seed production mainly depends on quality of seeds, agronomic practices and, plant protection measures are taken to produce a healthy and vigorous crop. Among various agronomic practices, nutrient management through the use of fertilizers is considered as an important factor for seed production. Onion growth and yield are very much dependent upon the application of minerals [8]. Chemical fertilizers are an inorganic source which is admixed into the soil to provide essential nutrients for improved plant growth and development [9, 10]. For enhanced plant growth, bulb yield, quality of bulbs and good quality seeds, the use of nitrogen, phosphorus and potassium are considered as essential [11]. Being the most important and vital component of protein and nucleic acid, N availability is of prime importance for growing plants [12]. It is also an essential component of many bio-molecules and is a part of some or many enzymes and coenzymes associated with chlorophyll synthesis, photosynthesis and crop yield development [13]. The beneficial effect of nitrogen application on onion yield was noted [14-18]. A significant increase in seed germination, flowering scape, umbel size and seed yield with N-application at 120 kg ha^{-1} was reported [19]. It was also obtained good onion growth at maximum (138 kg ha^{-1}) N-level [20]. Likewise, phosphorus is also vital nutrient element that stimulates the development of root, increases the strength of stem, seed production, earlier and even crop maturity, improved crop quality having more resistance to diseases [21]. Increased seed production was recorded by using 80 and 60 kg N&P, which increased No. of scape, umbel size, seeds (umbel^{-1}) and seed yield (plant^{-1}) [22]. In accordance, potassium regulates opening and closing of stomata during photosynthesis. It plays a vital role in protein synthesis, ionic balance, enzymes activation and adenosine triphosphate (ATP) production [23]. Hence, for the economic feasibility of onion, a balanced ratio of primary macro-nutrients (NPK) is prerequisite for better onion production. It was found that 80-60-40 kg NPK ha^{-1} resulted in more leaves and massive bulb production, which in turn produced highest onion yield [24]. While, an increment in onion plant growth, bulb quality and yield with the use of increased level of mineral fertilizers was also observed [25]. It was observed that application NPK (120-130-160 kg ha^{-1}) excelled onion bulb yield [26]. Owing to facts mentioned above, this research work was planned to determine the performance of onion (cv. Shah Alam) for better seed production under different NPK combinations.

Materials and methods

A research trial under field conditions was carried out to check the efficacy of multiple fertilizer combinations to onion (cv. Shah Alam) seed production at Agricultural Research Institute, Dera Ismail Khan, Pakistan, during 2015-16. A randomized complete block design was used to carry out experiment having eight different fertilizer combinations and three replications. Net plot size of 3 m × 3 m (9 m^2) was maintained for carrying out the trial. Experimental field was prepared by plowing soil three times. Medium size (3-5 cm) bulbs of onion (cv. Shah Alam) were planted in the last week of October, keeping a distance of 30 and 10 cm between successive rows and plants, respectively. The seed crop was harvested later on during mid of June 2015. All the required cultural practices were kept constant for all experimental plots. The detail of experimental treatments is given as under;

T_1 : Control (no fertilizer)
T_2 : 30-20-00 kg NPK ha^{-1}
T_3 : 60-40-15 kg NPK ha^{-1}

T_4 : 90-60-30 kg NPK ha^{-1}
T_5 : 120-80-45 kg NPK ha^{-1}
T_6 : 150-100-60 kg NPK ha^{-1}
T_7 : 180-120-75 kg NPK ha^{-1}
T_8 : 210-160-90 kg NPK ha^{-1}

Data on different parameters viz. time to sprouting, No. of shoots (plant^{-1}), leaf length (cm), flowering stalks (plant^{-1}), stalk length (cm), No. of flowers (umbel^{-1}), umbel diameter (cm), 1000-seed weight (g) and seed yield (kg ha^{-1}) were collected and analyzed statistically by computing analysis of variance [27] and least significant difference test was used to check differences among the treatment means, if any.

Results and discussion

Time to sprouting

Significant results were recorded for time to sprouting (Table 1) against different fertilizer combinations. Data analysis showed that increasing rate of NPK delayed sprouting as maximum days (17.50) were recorded in T_8 (210-140-90) which was statistically similar to T_7 (180-120-75) and T_6 (150-100-60 kg NPK ha^{-1}) showing 17.30 and 16.85 days to sprouting, respectively. Statistically, the results for days to sprouting recorded in T_5 (120-80-45) and T_4 (90-60-30 kg NPK ha^{-1}) were at par with each other by taking 16.20 and 15.50 days, respectively. Whereas, control plots (T_1) took shortest time (13.50 days) to sprout. It was observed that sprouting was progressively delayed with increment of fertilizers levels. Our results are resembled with Jilani [28] who also reported significant differences in sprouting initiation and completion with the application of different NPK levels to multiple varieties of onion. Similarly, Ali *et al.* [29] also found significant variations in days taken for bulb emergence due to various rates of N&P for onion seed production.

Number of shoots (plant^{-1})

Significant variations existed in the number of a shoot (Table 1) due to the application of multiple fertilizer combinations. An increment in NPK levels increased the number of onion shoots as maximum shoots (6.48 plant^{-1}) were recorded in T_8 (210-140-90 kg NPK ha^{-1}). It was statistically similar to T_7 (180-120-75), T_6 (150-100-60) and T_5 (120-80-45 kg NPK ha^{-1}) with 5.78, 5.13 and 5.00 shoots plant^{-1}, respectively. The results obtained in T_2 (30-20-00), T_3 (60-40-15) and T_4 (90-60-30 kg NPK ha^{-1}) were statistically at par with each other by producing 4.45, 4.87 with 4.97 shoots plant^{-1}, respectively. Whereas, minimum shoots (4.27 plant^{-1}) were found in control plots where no fertilizer was applied. These findings conform with Khalid and Shedeed [30] who reported that the number of shoots increased under various levels of NPK. Similarly, Desuki *et al.* [25] and Abdissa *et al.* [14] also reported an increase in onion vegetative growth with an increase in mineral fertilizer application.

Leaf length (cm)

A progressive increment in leaf length was noticed with an increase in fertilizer rates. Significant variations existed in leaf length among the treatments (Table 1). The maximum leaf length (41.20 cm) was recorded in T_8 (210-140-90). It was statistically similar with T_7 (180-120-75) and T_6 (150-100-60 kg NPK ha^{-1}) which showed 39.00 and 38.15 cm long leaves, respectively. The results were found intermediate in T_5 (120-80-45) and T_4 (90-60-30 kg NPK ha^{-1}) with 37.00 and 35.60 cm longer leaves, respectively. The shortest leaves (29.75 cm) were obtained in plots grown without any fertilizer addition i.e. T_1 (control). The result showed that leaf length increased when higher doses of NPK were applied. The reason for this might be the application of macro-nutrients at higher rates which played very efficiently in vegetative growth and leaf length. Jilani [28] and Pandey *et al.* [31] also reported significantly longest leaf blades by application of different doses of NPK to various cultivars of onion. Similarly, Adem and Tadesse [32] also reported an increase in leaf length in garlic when the higher doses of NP were used.

Flowering stalks (plant^{-1})

Although non-significant variations were observed among the treatments, however, an increasing trend in flowering stalks was observed (Table 1). Maximum flowering stalks (19.40 plant^{-1}) were recorded in T_8 with highest NPK dose (210-140-90 kg NPK ha^{-1}). The plots received no fertilizers i.e. T_1 (control) showed un-fertilized plants and possessed lowest flowering stalks (15.60 plant $^{-1}$). It was reported by Alla *et al.* [33] that fertilizers application did not affect this trait as it is a genetic character. These results are also in affirmation with Yaso and Razak [34] who found almost similar results for number flower stalks as affected by different NPK combinations.

Table 1. Time to sprouting, number of shoots (plant^{-1}), leaf length (cm), flowering stalks (plant^{-1}) and stalk length (cm) of onion as affected by different NPK fertilizers combinations (*Means followed by similar letter(s) do not differ significantly at 5% level of significance*)

NPK fertilizer combinations (kg ha^{-1})	Time to sprouting	No. of shoots (plant^{-1})	Leaf length (cm)	Flowering stalks (plant^{-1})	Stalk length (cm)
T_1 : Control	13.50 f	4.27 c	29.75 h	15.60	55.07 c
T_2 : 30–20–00	14.20 ef	4.45 bc	31.00 g	16.65	55.40 c
T_3 : 60–40–15	14.80 de	4.84 bc	33.50 f	17.00	55.55 c
T_4 : 90–60–30	15.50 cd	4.97 bc	35.60 e	17.55	56.10 c
T_5 : 120–80–45	16.20 bc	5.00 abc	37.00 d	18.25	57.73 c
T_6 : 150–100–60	16.85 ab	5.13 abc	38.15 c	18.30	59.68 bc
T_7 : 180–120–75	17.30 ab	5.78 ab	39.00 b	18.50	65.93 ab
T_8 : 210–140–90	17.50 a	6.48 a	41.20 a	19.40	67.10 a
$LSD_{0.05}$	**1.16**	**1.50**	**0.79**	**NS**	**7.41**
NPK fertilizer combinations (kg ha^{-1})	**No. of flowers (umbel^{-1})**	**Umbel diameter (cm)**	**1000-seed weight (g)**		**Seed yield (kg ha^{-1})**
T_1 : Control	266.61 e	4.35 d	2.73 d		194.20 g
T_2 : 30–20–00	278.20 de	4.92 c	2.78 d		232.50 f
T_3 : 60–40–15	285.00 d	4.96 c	2.84 c		270.00 e
T_4 : 90–60–30	302.50 c	5.54 b	2.86 c		325.80 d
T_5 : 120–80–45	315.70 c	5.65 b	2.92 b		360.50 c
T_6 : 150–100–60	345.60 b	5.88 b	2.96 b		385.00 b
T_7 : 180–120–75	366.22 a	5.87 b	3.05 a		410.20 a
T_8 : 210–140–90	372.22 a	6.45 a	3.03 a		420.00 a
$LSD_{0.05}$	**15.33**	**0.52**	**0.05**		**16.25**

Length of flowering stalks (cm)
The perusal of data presented in (Table 1) revealed that multiple fertilizers combinations increased the length of flowering stalks. The most extended flowering stalks (67.10 cm) were obtained in T_8 (210-140-90) which was statistically akin with T_7 (180-120-75) and T_6 (150-100-60 kg NPK ha^{-1}) by producing 65.93 cm and 59.68 cm long flowering stalks, respectively. It was also observed that the results from T1 up to T5 were statistically at par with each other showing no significance. Enhancement of flowering stalks length with the application of NPK fertilizers at higher rates indicated that adequate supply of macro-nutrients improved flower characteristics of onion (cv. Shah Alam) in agro-ecology of Dera Ismail Khan. Our results are supported by Jilani **[28]** who also reported longer flowering stalks by application of different doses of NPK fertilizers to different varieties of onion. Similarly, Abas *et al.* **[35]** also reported a maximum length of the flowering stalk with a higher doze of N application.

Number of flowers (umbel^{-1})
Significant variations observed in the number of flowers due to variable application of NPK fertilizers (Table 1). The results showed an increased number of flowers with increased rates of NPK, as maximum flowers (372.22 umbel^{-1}) was recorded in T_8 (210-140-90) followed by T_7 (180-120-75 kg NPK ha^{-1}) which produced 366.22 flowers umbel^{-1} and both treatments were statistically alike. Statistically, similar response for flowers was found in T_5 (120-80-45) and T_4 (90-60-30 kg NPK ha^{-1}) with 315.70 and 302.50 flowers umbel^{-1}, respectively. While the minimum number of flowers (266.61 umbel^{-1}) was observed in un-fertilized plants T_1 (control) which differed significantly from all other treatments except T_2 (30-20-00 kg NPK ha^{-1}) which produced 278.20 flowers umbel^{-1}. Similar findings were reported by Ali *et al.* **[29]** and Abas *et al.* **[35]** who recorded greater number of flowers by application of different doses of NK.

Umbel diameter (cm)
Results pertaining to umbel diameter expressed significant differences with multiple fertilizer combinations (Table 1). An increased rate of NPK in T_8 (210-140-90 kg ha^{-1}) produced significantly maximum umbel diameter (6.45 cm). It was followed by T_7 (150-100-60), T_6 (180-120-75), T_5 (120-80-45) and T_4 (90-60-30 kg NPK ha^{-1}) with 5.88, 5.87, 5.65 and 5.54 cm umbel diameter, respectively. All these treatments were statistically non-significant with each other. The un-fertilized plants in T_1 (control) produced minimum umbel diameter (4.35 cm) which also differed statistically from all other treatments. Statistically, similar umbel diameter of 4.92 and 4.96 cm were recorded in T_2 (30-20-00) and T_3 (60-40-15 kg NPK ha^{-1}), accordingly. Our results resemble with Bhardwaj **[22]** who also found increased onion umbel diameter with augmented fertilizer applications. Likewise, Ali *et al.* **[29]** also recorded greater umbel diameter and highest fruits set per umbel with implementation of different doses of NK.

1000-seed weight (g)
Data given in (Table 1) showed that thousand seed weight increased with an increase in nutrients (NPK) application. Maximum seed weight (3.05 g) was achieved in T_7 (180-120-75) which was very closely followed by T_8 (210-140-90 kg NPK ha^{-1}) which produced of 3.03 g seed weight, while both treatments were significantly similar with each other. Likewise, results recorded in T_6 (150-100-60) and T_5 (120-80-45) also showed statistically similar seed indices (2.96 and 2.92 g), respectively. The minimum seed weight (2.73 g) was achieved in T_1 (control) which was at par with T_2 (30-20-00) producing 2.78 g seed weight. These findings are supported by Ali *et al.* **[29]** who reported significant variations (2.87 to 3.01 g) in thousand seed index. Similarly, Gasim and George **[36]** reported significant effect on seed quality due to NPK

application. Increased seed weight in highest NPK treatments might be due to more availability of nutrients that produced, healthy and heavier seeds [37, 38].

Seed yield (kg ha^{-1})

Data analysis revealed that fertilizer combinations enhanced onion seed yield (Table 1). Highest seed yield (420 kg ha^{-1}) was achieved by using higher NPK dose T_8 (210-140-90) which was very closely followed by T_7 (180-120-75 kg NPK ha^{-1}) producing seed yield of 410 kg ha^{-1} and both treatments were statistically identical. Minimum (194 kg ha^{-1}) seed yield was achieved from control plots (T_1) which differed significantly from all other treatments. Enhancement in seed yields was recorded by Ali *et al*. [29] with the addition of multiple levels of N and K. Similarly, higher seed yield with the application of varying doses of NPK was observed by Aminpour *et al*. [39]. However, Ayala *et al*. [40] reported higher seed yield with the application of NPK @ 153-37-14 kg ha^{-1}. The possible reason of this yield increase be the maximum length of leaves. It promoted the photosynthetic activities and efficient utilization of photosynthates from leaves to reproductive parts of plant. This improvement resulted in enhanced seed fillings with better and more number of flowers per umbel, thus, resulting in maximum seed yield [41].

Conclusion

The results of the current experiment indicated that application of NPK proved beneficial for onion seed yield. It is concluded that the application of 180-120-75 kg NPK ha^{-1} should be appropriate for obtaining increased and profitable seed yield of onion under the agro-ecology of Dera Ismail Khan, Pakistan. Moreover, the use of 210-140-90 kg NPK ha^{-1} is also a viable option for getting maximized production of onion, if the prices of different inputs and fertilizers are reasonable.

Authors' contributions

Conceived and designed the experiments: S Jilani & Faridullah, Performed the experiments: S Jilani & Faridullah, Analyzed the data: S Fatima, M Kiran & TA Jilani, Statistical analysis: MA Nadim, Wrote the paper: M Sohail & K Waseem

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