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Growth and yield of bulbs of onion (*Allium cepa* L.) as influenced by different levels of nitrogen, phosphorous, potassium and sulphur

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Abstract
An investigation entitled "Growth and yield of bulbs of Onion (*Allium cepa* L.) as influenced by different levels of Nitrogen, Phosphorous, Potassium and Sulphur" was conducted during 2016-17 in Randomized Block Design (RBD) with three replication to assess the impact of NPK and sulphur doses on growth and yield of bulbs of Onion. Total ten treatments were tried and it was concluded that the dose of 100 kg N +50 kg P_2O_5 +50 kg K_2O + 45 kg sulphur ha^{-1} was found to be superior in terms of all growth parameters, yield and yield attributing character of Onion in profitable manner as compared to control and further treatments. The various growth, yield and yield attributing parameters i.e. plant height (39.03 cm), number of leaves $plant^{-1}$(12.93), diameter of stem (0.91 cm), length of longest leaves (29.57 cm), neck thickness (0.91 cm), shell thickness (0.22 mm), bulb diameter (5.31 cm), length of bulb (4.89 cm), weight of bulb (53.40 g), fresh yield of bulb $plot^{-1}$ (7.61 kg), marketable yield of bulbs (250.33 q ha^{-1}), TSS content in onion juice (15.67%), were observed with highest mean values and minimum under control i.e., plant height (28.50 cm), number of leaves $plant^{-1}$ (8.00), diameter of stem (0.62 cm), length of longest leaves (17.83 cm) at 90 DAP near to harvest and neck thickness (0.64 cm), shell thickness (0.12 mm), bulb diameter (2.69 cm), length of bulb (2.56 cm), weight of bulb (34.00 g), fresh yield of bulb $plot^{-1}$ (4.84 kg), marketable yield of bulbs (158.00 q ha^{-1}), TSS content in onion juice (10.07%) at harvest.

Keywords: Onion, Nitrogen, Phosphorus, Potassium, sulphur, growth and yield

Introduction
Onion (*Allium cepa* L.) is most important bulbous vegetable crop. It belongs to family Alliaceae and genera *Allium*. It is originated from Central Asia. It is an important vegetable crop grown in India. India exports 12 per cent of total world export of onion. It is more than 75% of foreign exchange that comes from export of fresh vegetables. It is a biennial plant, but is usually grown as an annual and shallow rooted crop. It is basically long day plant for bulb production and grown during *rabi* season. Due to the development of new improved cultivars, it can also be grown in *kharif* season. The various compounds like allicin, allin and sulphites etc. are abundantly present in onion bulbs. These compounds are helps to fighting cancer, high blood cholesterol and sugar, liver problems and intestinal problems. It has diuretic and simulative properties. Onion is photo-thermo sensitive, long day crop having distinct effect of photoperiod and temperature on vegetative growth, bulb development and bulb maturity. It is thought to have been first domesticated in the mountainous regions of Turkmenia, Uzbekistan, Tajikistan, North Iran, Afghanistan and Pakistan. The onions are distributed widely through temperature, warm temperature and boreal zones of the Northern hemisphere. Vegetatively propagated variants of an *Allium cepa* which are grown in many parts of the tropics are shallots and multiplier onion (Geri, 2014) [7]. Most of the vegetables are being produced by using various major plant nutrients like nitrogen, phosphorous and potassium. These plant nutrients are essentially important for growth, yield and yield attributes of onion bulbs. Besides these nutrients, sulphur requirement has also been reported. It is well known fact that the proper nutrition of the bulbous vegetable has a great potential for in Indian soils to obtained good quality onion bulbs with higher yield. Nitrogen is key component of enzymes, vitamins, chlorophyll and other cell constitutes, all of which are essential for crop growth and development. 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 [12] and Al-Fraihat, 2009 [1]). Phosphorous play an important role in the production of vegetable crops, it imparts hardiness to shoot, increased size of bulb and quality, regulates the photosynthesis, governs physico-biochemical processes and helps root enlargement. Phosphorus which is associated with basic phytometabolic processes inclusive of a large number of enzymatic reactions. Since phosphorus is a constituent of compounds of various biochemical compositions, it serves as an anti-force against the ills of injudicious and unauthentic application of nitrogen, and maintains a balance in blooming and fruit and seed - setting, ultimately dispensing with a normal maturity of crop **(**Singh, 1991 [18]). Potassium is a major plant nutrient, which is needed by the plants in large amount and is supplied by the fertilizer. Potassium plays a vital role in plant metabolism such as photosynthesis, translocation of photosynthates, regulation of plant pores, activation of plant catalysts and resistance against pests and diseases. It is also considered as a quality element as it improves quality parameters of many crops including onion. Potassium improves colour, glossiness and dry matter accumulation besides improving keeping quality of the onion (Salimath, 1990 [15]). Sulphur is one of the important nutrients receiving greater attention due to its proven deficiency in commercial crops all over the world causing 10 to 34 percent yield reductions. Role of sulphur is particularly important in the nutrient of onion as is constituent of allin, cycloallin and thiopropanol. Sulphur plays an important role by influencing synthesis of proteins, formation of amino acids chlorophyll as well as development of bulbs (Singh and Singh, 2003 [17]).

Materials and Methods-

An experiment was conducted at Horticulture Research Center of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.) during the year 2016-2017. The experiment was laid out in Randomized Block Design (RBD) and replicated thrice. Total ten treatment that is to say **T_1**- 80 kg N +40 kg P_2O_5 +40 kg K_2O + 15 kg sulphur ha^{-1}, **T_2**- 80 kg N +40 kg P_2O_5 +40 kg K_2O + 30 kg sulphur ha^{-1}, **T_3**- 80 kg N +40 kg P_2O_5 +40 kg K_2O + 45 kg sulphur ha^{-1}, **T_4**- 100 kg N +50 kg P_2O_5 +50 kg K_2O + 15 kg sulphur ha^{-1}, **T_5**- 100 kg N +50 kg P_2O_5 +50 kg K_2O + 30 kg sulphur ha^{-1}, **T_6**- 100 kg N +50 kg P_2O_5 +50 kg K_2O + 45 kg sulphur ha^{-1}, **T_7**- 120 kg N +60 kg P_2O_5 +60 kg K_2O + 15 kg sulphur ha^{-1}, **T_8**- 120 kg N +60 kg P_2O_5 +60 kg K_2O + 30 kg sulphur ha^{-1}, **T_9**- 120 kg N +60 kg P_2O_5 +60 kg K_2O + 45 kg sulphur ha^{-1} and **T_{10}**- control. The pH of soil was 7.70 with sandy loam texture and having available nitrogen (149.80 kg ha^{-1}), available phosphorus (24.18 kg ha^{-1}) and available potassium (113 kg ha^{-1}).The onion variety Agrifound Dark Red was taken for study and developed through selection from locality of Nasik and recommended for commercial cultivation in northern plains of India. The treated seed were sown in nursery beds at a spacing of 10 x 10 cm and seeds covered with locally available mulch material. The mulch was eradicated when seeds get germination and care was done properly up to obtained healthy seedlings in standard height i.e., 8-10 cm. Ready seedlings were transplanted in experimental plot at a spacing 20x10 cm. At the time transplanting, all the NPK and sulphur doses were applied as basal dose as per the treatment combination. The full dose of phosphorus, potash, elemental sulphur and half of nitrogen was applied in plots and mixed in soil before transplanting as per the treatments suggested. The remaining half dose of nitrogen was given as top dressing in two split doses at 30 days and 45 days after transplanting. All the cultural practices were done at regular intervals as per the requirement of crop during the course of investigation. Similarly, plant protection measures were also done with spraying fungicides like Mancozeb to save crop from diseases. During the experimentation, various observations on growth, yield and yield attributing parameters were recorded during the cropping period. The obtained data were statistically analyzed with using standard statistical method as suggested by Gomez and Gomez (1996) [10].

Result and Discussion

Effect of NPK and sulphur doses on growth parameters-

The various growth parameters like plant height, number of leaves $plant^{-1}$, diameter of stem $plant^{-1}$ and length of longest leaves $plant^{-1}$ of onion were significantly influenced by different doses of nitrogen, phosphorus, potassium and sulphur as compared to control and other applied treatment during the course of investigation. The data presented in Table-1 revealed that plant height and number of leaves $plant^{-1}$ were significantly improved with the application of different doses of nitrogen, phosphorus, potassium and sulphur up to certain treatment, thereafter it was slightly reduced the plant height and number of leaves $plant^{-1}$ as compared to control. The maximum plant height (39.03 cm) and maximum number of leaves $plant^{-1}$(12.93) were recorded the treatment related to T_6 (100 kg N + 50 kg P_2O_5 + 50 kg K_2O + 45 kg sulphur ha^{-1}) followed by T_7- 120 kg N + 60 kg P_2O_5 + 60 kg K_2O + 15 kg sulphur ha^{-1}, while the minimum plant height (28.50 cm) and number of leaves $plant^{-1}$ (8.00) were observed in control (T_{10}). The growth of plant was found satisfactory by using combined dose of major nutrients like nitrogen, phosphorous and potassium with secondary nutrient like sulphur at optimum level. Therefore, it might be due to application of nitrogen, phosphorus, potassium and sulphur fertilizers increased the cell division, cell elongation synthesis of the different components of protein, increased production of carbohydrate, constituent of the cell nucleus and translocation of photosynthesis. These result are may be close agreement with the finding of Singh *et al*. (2000) [19], Singh *et al.* (2004) [20], Bassiony (2006) [4] and Nasreen *et al*. (2007) [12]. An application of 100 kg N + 50 kg P_2O_5 + 50 kg K_2O + 45 kg sulphur ha^{-1} had significant effect on diameter of stem $plant^{-1}$ and length of longest leaves $plant^{-1}$ of onion with the relationship of control and other treatments. Maximum diameter of stem $plant^{-1}$ (0.91 cm) and maximum length of longest leaves $plant^{-1}$ (29.57 cm) were recorded in T_6- (100 kg N + 50 kg P_2O_5 + 50 kg K_2O + 45 kg sulphur ha^{-1}) followed by T_7- 120 kg N + 60 kg P_2O_5 + 60 kg K_2O + 15 kg sulphur ha^{-1}, while the minimum diameter of stem $plant^{-1}$ (0.62 cm) and minimum length of longest leaves $plant^{-1}$ (17.83 cm) were pragmatic in control (T_{10}). The Vigorous growth of onion in terms of diameter of stem $plant^{-1}$ and length of longest leaves $plant^{-1}$ might be due to the application of nitrogen, phosphorus, potassium and sulphur fertilizers increased the constituent of chlorophyll, increased synthesis of photosynthates, encouraged meristematic activity of plants in horizontally and vertically, increased protein and carbohydrate metabolism in plants. Similar results have also been reported by Channagoudra (2004) [6], Jaggi (2005) [11] and Brinjh *et al*. (2014) [5].

Table 1: Effect of NPK and sulphur doses on growth characters of onion (*Allium cepa* L.)

Treatments	Plant height (cm)	Number of leaves	Diameter of stem (cm)	Length of longest leaf (cm)
T_1- 80 kg N +40 kg P_2O_5 +40 kg K_2O + 15 kg Sulphur ha^{-1}	32.33	9.20	0.74	22.87
T_2 -80 kg N +40 kg P_2O_5 +40 kg K_2O + 30 kg Sulphur ha^{-1}	33.43	9.80	0.77	23.93
T_3 -80 kg N +40 kg P_2O_5 +40 kg K_2O + 45 kg Sulphur ha^{-1}	34.60	10.40	0.80	25.07
T_4 -100 kg N +50 kg P_2O_5 +50 kg K_2O + 15 kg Sulphur ha^{-1}	35.87	11.13	0.83	26.37
T_5 -100 kg N +50 kg P_2O_5 +50 kg K_2O + 30 kg Sulphur ha^{-1}	36.52	11.61	0.84	27.46
T_6 -100 kg N +50 kg P_2O_5 +50 kg K_2O + 45 kg Sulphur ha^{-1}	39.03	12.93	0.91	29.57
T_7-120 kg N +60 kg P_2O_5 +60 kg K_2O + 15 kg Sulphur ha^{-1}	37.27	11.89	0.86	27.78
T_8-120 kg N +60 kg P_2O_5 +60 kg K_2O + 30 kg Sulphur ha^{-1}	35.10	10.73	0.81	25.5
T_9 -120 kg N +60 kg P_2O_5 +60 kg K_2O + 45 kg Sulphur ha^{-1}	33.67	10.07	0.78	24.2
T_{10} – Control	28.50	8.00	0.62	17.83
S.Em	**1.21**	**`0.37**	**0.03**	**0.86**
C. D. at 5% of level	**3.49**	**1.06**	**0.08**	**2.50**

Effect of NPK and sulphur doses on yield parameters-

Yield and yield attributing parameters like neck thickness (cm), shell thickness (mm), bulb diameter (cm), length of bulb (cm), weight of bulb (g), fresh yield of bulb $plot^{-1}$ (kg) and marketable yield of bulbs (q ha^{-1}) of onion were significantly predisposed by different doses of nitrogen, phosphorus, potassium and sulphur as compared to control and other levels of treatments during the path of exploration. The parameters like neck thickness and shell thickness of onion bulb were influenced by different doses of nitrogen, phosphorus, potassium and sulphur in positive way in present investigation. The maximum neck thickness of bulb (0.91 cm) and maximum shell thickness of bulb (0.22 mm) were experiential with an application of 100 kg N + 50 kg P_2O_5 + 50 kg K_2O + 45 kg sulphur ha^{-1}(T6) followed by T_7- 120 kg N + 60 kg P_2O_5 + 60 kg K_2O + 15 kg sulphur ha^{-1}, while minimum neck thickness of bulb (0.64 cm) and shell thickness of bulb (0.12 mm) under control (T_{10}). The increases in neck thickness and shell thickness might be due to increased uptake of NPK and sulphur by crop which enhanced the synthesis and translocation of photosynthates to the bulbs and the storage organs of the onion, resulting higher dry matter accumulation in cover and neck portion of the bulbs. Similar result also has been reported by Jaggi (2005) [11], Pradhan *et al*. (2015) [14] and Shankaran *et al*. (2005) [16] in onion bulbous crop. In other hand, yield attributing parameters i.e., diameter of bulb and length of bulbs were also found superior with various doses of NPK and Sulphur during course of investigation. The maximum diameter of bulb (5.31 cm) and highest length of bulb (4.89 cm) were calculated in T_6- 100 kg N + 50 kg P_2O_5 + 50 kg K_2O + 45 kg sulphur ha^{-1} followed by T_7- 120 kg N + 60 kg P_2O_5 + 60 kg K_2O + 15 kg sulphur ha^{-1}, whereas the minimum bulb diameter (2.69 cm) and length of bulb (2.56 cm) were distinguished in control (T_{10}). The above dose favoured the bulb diameter and length of bulbs due to increased carbohydrate, regulation of starch, dry matter production and translocation of photosynthates contributed to the swelling of bulbs which resulted in increased diameter and length of bulb. Translocation of photosynthates contributed to the swelling of bulbs which resulted in increased diameter. These findings are in line with Aliuy *et al.* (2007) [3], Soleymani and Shahrajabian (2012) [21], Nasreen *et al.* (2007) [12], Poornima *et al.* (2015) [13] and Dudhat *et al.* (2011) [7]. Similarly, the other yield contributing parameters like weight of bulb and yield of bulb plot-1 had significant relationship with marketable yield as application of various doses of NPK and sulphur. The maximum weight of bulb (53.40 g), the highest bulb yield $plot^{-1}$ (7.61 kg) and maximum marketable yield of bulb (250.33 q ha^{-1}) were notified with a dose of 100 kg N + 50 kg P_2O_5 + 50 kg K_2O + 45 kg sulphur ha^{-1} (T6) followed by T_7- 120 kg N + 60 kg P_2O_5 + 60 kg K_2O + 15 kg sulphur ha^{-1}, while minimum weight of bulb (35.20 g), the highest bulb yield $plot^{-1}$ (5.02 kg) and maximum marketable yield of bulb (164.00 q ha^{-1}) were experienced under unfertilized plot (T_{10}-control).Balanced application of macro and secondary nutrient application were gave the significant effect on marketable yield and yield attributing characters during course of investigation. The improvement in yield may be due to higher uptake of nitrogen, phosphorus, potassium and sulphur by the onion crop resulting higher chlorophyll, increased enzymatic and protein synthesis, proper root proliferation, and enhancing the translocation of assimilates. The above research findings are close in conformity with the earlier findings given by El- Desuki *et al*. (2006) [8], Ali *et al.* (2007) [2], Yadav *et al*. (2015) [23] and Uikey *et al.* (2015) [22].

Table 2: Effect of NPK and sulphur doses on yield and yield attributing characters of onion

Treatment	Neck thickness (cm)	Shell thickness (mm)	Bulb diameter (cm)	Bulb length (cm)	Weight of bulb (g)	fresh yield of bulb $plot^{-1}$ (kg)	Marketable yield of bulbs (q ha^{-1})
T_1- 80 kg N +40 kg P_2O_5 +40 kg K_2O + 15 kg Sulphur ha^{-1}	0.69	0.13	2.98	2.84	38.50	5.49	179.67
T_2 -80 kg N +40 kg P_2O_5 +40 kg K_2O + 30 kg Sulphur ha^{-1}	0.73	0.14	3.32	3.21	41.30	5.89	193.00
T_3 -80 kg N +40 kg P_2O_5 +40 kg K_2O + 45 kg Sulphur ha^{-1}	0.77	0.16	3.76	3.45	44.70	6.37	209.00
T_4 -100 kg N +50 kg P_2O_5 +50 kg K_2O + 15 kg Sulphur ha^{-1}	0.80	0.18	4.20	3.83	46.80	6.67	219.00
T_5 -100 kg N +50 kg P_2O_5 +50 kg K_2O + 30 kg Sulphur ha^{-1}	0.84	0.19	4.75	4.28	49.50	7.05	232.33
T_6 -100 kg N +50 kg P_2O_5 +50 kg K_2O + 45 kg Sulphur ha^{-1}	0.91	0.22	5.31	4.89	53.40	7.61	250.33
T_7-120 kg N +60 kg P_2O_5 +60 kg K_2O + 15 kg Sulphur ha^{-1}	0.89	0.20	4.82	4.47	51.00	7.26	239.00
T_8-120 kg N +60 kg P_2O_5 +60 kg K_2O + 30 kg Sulphur ha^{-1}	0.83	0.17	4.37	3.96	48.60	6.93	227.00
T_9 -120 kg N +60 kg P_2O_5 +60 kg K_2O + 45 kg Sulphur ha^{-1}	0.79	0.15	3.92	3.43	47.30	6.74	221.67
T_{10} – Control	0.64	0.12	2.69	2.56	35.20	5.02	164.00
S.Em	0.01	0.00	0.14	0.13	0.84	0.08	3.38
C. D. at 5% of level	0.02	0.00	0.40	0.37	2.24	0.24	9.49

Conclusion-

On the basis of results summarized above findings of present investigation, it can be concluded that an application of 100 kg N + 50 kg P_2O_5 + 50 kg K_2O + 45 kg sulphur ha^{-1} was found to be superior in terms of growth, yield and yield attributing parameters of onion as compared to control and other treatments.

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