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Effect of nutrients and plant growth regulators on yield and quality of onion (*Allium cepa* L.)

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Abstract
To enhance productivity and food safety Indian Agriculture become more mechanized and science based by using nutrients, plant growth regulators and curing are among of them; These treatment are quicker impact on yield as well as quality of the crops. The field experiment was conducted to study the “Effect of Nutrients and Plant Growth Regulators on Growth, Yield, Quality and Storage Life of Onion (*Allium cepa* L.)” in loamy sand soils of the Research Farm, Rajasthan Agricultural Research Institute Durgapura (Jaipur, Rajasthan) during *rabi* season 2016-17 and 2017-18. The experiment consisted four nutrient combination (NP, NPK, NPKS and NPKSB) and four treatment were nutrient and plant growth regulators (Control, $CaCl_2$ @ 0.5%, ethephon @ 3000 ppm and mepiquat chloride @ 750 ppm) under three curing methods (Field curing, curing under 60% shade and curing under poly tunnel) thereby making forty-eight treatment combinations tested in randomized block design with three replications. Results indicated that application of NPKSB and mepiquat chloride@750 ppm significantly higher yield and quality attributes of onion over other treatment. The result also indicated the field curing significantly minimized the neck thickness and increased total soluble solids over poly tunnel curing and 60% shade net curing.

Keywords: Bulb yield, onion, pant growth regulators, nutrients

Introduction
Onion (*Allium cepa* L.) is one of the most important commercial vegetable crops cultivated extensively in India and it belongs to family *Alliaceae*. Onion is an indispensable item in every kitchen as vegetable and condiment, therefore commands, an extensive internal market. Onion is liked for its flavour and pungency which is due to the presence of a volatile oil ‘*allyl propyl disulphide*’- organic compound rich in sulphur. Onion is used in pharmaceutical preparations due to its medicinal values. Onion is also known to cure heart diseases as it checks the deposition of cholesterol in blood vessels.

Availability of nitrogen is important for growing plants as it is major indispensable constituent of protein and nucleic acid. Similarly, Phosphorus is indispensable constituent of nucleic acids, phospholipids and several enzymes. It is also needed for the transfer of energy within the plant system and is involved in its various metabolic activities (Yalwalker *et al*., 1962). Potassium imparts vigour and disease resistance to the plant and plays an important role in crop productivity. The essential role of K in numerous physiological and biochemical processes in the plants including photosynthesis, enhancing the translocation of assimilates, protein synthesis, maintenance of water balance, and promoting enzyme activities are well established (Marschner, 2012) [3]. An adequate K content of the bulb is also important for storage quality of the crop. Potassium improves color, glossiness and dry matter accumulation besides improving, it also keeping bulb quality of onion (Dorais *et al*., 2001) [4].

Likewise, sulphur is an essential constituent of certain amino acids namely cysteine and methionine and involved in synthesis of proteins and sulphur bearing vitamins like biotine, thiamine and some co-enzymes. It is a constituent of “Allyl propyl disulphide” which imparts the pungency in onion. The application of sulphur improves plant height, number of leaves, bulb diameter, bulb weight and yield of onion (Jana *et al*. 1990) [5]. The pungency in onion is due to sulphur- bearing compound in very small quantity (about 0.005%) in the volatile oil, allyl propyl disulphide (C6H12O2). Boron is essential for normal transport of water, nutrients and photosynthetic sugars to rapidly developing meristemetic tissues, such as root tips, leaves, buds and storage tissues. Application of boron can increase bulb size and yield of onion (Smriti *et al*., 2002) [6]. Boron deficiency affects reproductive growth more than vegetative growth. Accumulation of carbohydrates in leaves under calcium stress decrease carbohydrate content of stems and roots, which impairs normal root function. According to John (1987) [7], calcium improves rigidity of cell walls and obstructs enzymes such as polygalcturonase from reaching their active sites, thereby, retarding tissue softening and delaying ripening. Calcium application maintains cell turgor, membrane integrity, tissue firmness and delays membrane lipid catabolism thus, extending storage life (Chaplin and Scott, 1980) [8]. Moreover, calcium existing in fruit tissues usually prevents post-harvest disorders, retards ripening and decreases post-harvest fruit weight losses and decay (Lara *et al*., 2004) [9].

Mepiquat chloride is formed from the reaction between N-methylpiperidine and chloromethane in an anhydrous liquid solvent selected from the group consisting of acetone, methyl ethyl ketone, toluene, tetrahydrofuran, isopropanol, acetonitrile, N,N dimethylformamide and methylene chloride in the absence of sodium hydroxide. Mepiquat chloride precipitates as a solid of high purity and is recovered under a substantially moisture-free atmosphere. Mepiquat chloride is used as a component of a system for growing a number of commodity plants and increases photosynthetic rate by increasing leaf chlorophyll content and mesophyll cell. Mepiquat chloride induce extension in storage life of onion might be due to anti-gibberellin action, which might have facilitated the maintenance of quality of bulbs in storage with respect to inhibition of sprouting, leading to reduction of moisture and physiological loss in weight (Rahman and Isenberg, 1974) [14].

Ethephon, a compound that releases ethylene, induces bulbing in onions grown under non inductive photoperiods. Ethrel played an important and pivotal role in increasing the bulb yield as it accelerated bulb enlargement and the photoperiodic phenomenon that induced synthesis, translocation and accumulation of assimilates resulting in increasing the bulb size. Inhibition of potato sprouting by continuous application of ethylene has long been known (Rylski *et al*., 1974) [10] and has found commercial application (Prange *et al*., 1998) [11].

Curing is the most important operation in the post-harvest processing of onion to be followed immediately after harvesting. Curing can be defined as removing the excess moisture from the outer layers of the bulb prior to storage (Maw *et al*., 2004) [15]. Curing decreases the incidence of neck rot, reduces water loss during storage, prevents microbial infection, and is desirable for development of good scale colour, thereby preserving the main edible tissue in a fresh state.

Materials and Methods

The experiment was conducted at the Research Farm, Rajasthan Agricultural Research Institute, Durgapura, Jaipur (Rajasthan). The region falls under Agro-Climatic Zone III- A (Semi-Arid Eastern Plain). Durgapura is situated at 26.5º North latitude, 75.47º East longitude and an altitude of 390 meters above Mean Sea Level in Jaipur district of Rajasthan. The initial soil fertility status of experimental plot was well drained clay loam with pH 8.00 and EC 0.80 ds m^{-1}. The available N, P, K and S content of the soil were 248.11, 11.14, 168.41 and 13.10 kg/ha, respectively. The experiment was laid out in Factorial Randomized Block Design with three replications and consisting of Forty-eight treatments are presented in Table (1). The onion cultivar RO-59 was sown in nursery beds during November and transplanted in January with space of 15x10 cm between rows and plants, respectively. All nutrients like NP, NPK, NPKS and NPKSB and nutrients and plant growth regulators *viz* field curing, curing under 60% shade and poly tunnel curing like control, CaCl2@0.5%, ethephon@3000 ppm and mepiquat chloride@750 ppm and curing. Fertilizers were applied as per treatment through Urea, DAP and MOP at the time of sowing as basal dose and split application of urea at top dressing. The 6-10 days interval irrigations were applied during growing season. Intercultural operations *viz.*, thinning, hoeing and weeding were followed after 20 days of sowing to maintain recommended spacing and weed control. Two hand weeding during growing period and harvest maturing in 50 to 55 days after sowing and observations on tagged plants were recorded.

Table 1: Treatment details

Nutrients	
N1	NP: 100: 50 kg/ha
N2	NPK: 100: 50: 150 kg/ha
N3	NPKS: 100: 50: 150: 45 kg/ha
N4	NPKSB: 100: 50: 150: 45: 1 kg/ha
Nutrient and plant growth regulators	
G1	Control
G2	$CaCl_2$(0.5%)
G3	Ethephon@3000 ppm
G4	Mepiquat chloride@750 ppm
Curing	
C1	Field curing
C2	Under 60% shade curing
C3	Under poly tunnel curing

Results and Discussion

The data on yield and yield attributes parameters and quality attributes as well as soil fertility status after harvest the crop as influenced by combined application of nutrients and plant growth regulators of the different treatments are presented in Table 2 and 3.

Effect of Nutrients

Yield is a complex character which depends on yield contributing characters. Since an adequate supply of nutrients may be explained on the basis that nutrients fed to plants might have made their rapid growth and acquired better green colour due to increased synthesis of chlorophyll content in the leaves, which enhanced net assimilation rate due to increased photosynthetic activities. Application of NPKSB significantly increases average bulb weight (76.26 g), polar diameter (4.99 cm), equatorial diameter (5.79 cm), total bulb yield (27.77 kg/plot and 425.83 q/ha) and marketable bulb yield (23.22 kg/plot and 386.36 q/ha). The same treatment also exhibited minimum thickness of neck (0.78 cm) of the bulbs. The increase in yield and yield attributes due to combined application nutrients might be due to its functional role in higher net photosynthetic activity. In addition, it has an indispensable role in translocation of carbohydrates from plant leaves towards bulbs (Black, 1960 and Bidwell, 1979) [12, 13]. The beneficial influence of phosphorus in early stage of growth might be explained by early stimulation of scanty root system through efficient translocation of certain growth stimulating compounds to the roots on account of protoplasmic activity in phosphorus fed plants, which enhanced absorption of nitrogen and other nutrients and their utilization. The increase in yield and yield attributes due to potassium application might be due to its functional role in higher net photosynthetic activity. In addition, it has an indispensable role in translocation of carbohydrates from plant leaves towards bulbs (Black, 1960 and Bidwell, 1979) [12, 13].

Sulphur application also proved effective in improvement in yield attributes of onion. Sulphur has a role in synthesis of sulfur containing amino acids, proteins, energy transformation and activation of enzymes, which in turn enhances carbohydrate metabolism and photosynthetic activity of plant with increased chlorophyll synthesis. Increase bulb yield due to sulphur application might be due to low available sulphur in experimental soil and better development and thickening of xylem and collenchyma because of higher rate of protein synthesis and enhanced photosynthetic activity of the plant with increased chlorophyll synthesis due to fertilization with sulphur (Biswas *et al.,* 1995). Nutrient application especially, boron, enhanced the enzyme activity which trigger the protein and carbohydrate metabolism in plants. The increase in yield might be due to role of boron in biosynthesis of indole acetic acid (IAA) and especially in initiation of primordia for reproductive parts and partitioning of photosynthates towards them, which resulted in better bulb formation in onion (Acharya *et al*., 2015).

Total soluble solids content in bulbs increased with the application of nutrients might be due to vigorous vegetative growth and deep green colour of foliage, which favoured photosynthetic activity of the plants so there was greater accumulation of food material i.e. carbohydrates in the bulb, which synthesized to saccharides and there was increase in total soluble solids content in bulbs. The sulphur content (0.748%), allyl propyl disulphide content (8.50 mg/g) in bulbs and uniformity of bulb size (85.10%) were recorded significantly higher with application of NPKSB. However, this treatment was remained statistically at par with NPKS in respect to total soluble solids in bulbs.

Effect of nutrients and plant growth regulators

The production of large sized bulbs with mepiquat chloride might be attributed to the fact that plant growth regulators remains physiologically more active to build up sufficient food reserves for developing bulbs, which ultimately leads to increased total bulb yield in garlic (Memane *et al*., 2008). Foliar application of mepiquat chloride @ 750 ppm was recorded significantly higher average bulb weight (73.16 g), polar bulb diameter (4.70 cm), equatorial bulb diameter (5.51 cm), total bulb yield (26.01 kg/plot and 409.01 q/ha) and marketable bulb yield (22.15 kg/plot and 372.28 q/ha) in onion crop. This treatment also exhibited minimum (0.92cm) neck thickness of bulb followed by ethephon @ 3000 ppm (0.95 cm). The improvement in the quality attributes might be due to the treatment of anti-gibberellin compound like mepiquat chloride, which facilitate the translocation of photo-assimilates from source to sink thereby enhancing bulb growth and enhancement of sink strength would be able to absorb the incoming sucrose more efficiently and converting into soluble forms as reported by Rees and morel, 1990 in potato. Foliar application of mepiquat chloride @ 750 ppm exhibited significantly higher total soluble solids (10.84%), sulphur content (0.735%), allyl propyl disulphide content (7.79 mg/g) in bulbs and uniformity of bulb size (84.03%). However, the same treatment was statistically identical with ethephon @ 3000 ppm in respect to total soluble solids in bulbs.

Effect of curing

Curing treatment allows bulbs to develop tough skin that limit exchange of gas with the external environment and by shrinking and closing the neck so that oxygen required for shoot growth and emergence is minimized. Curing methods in onion after harvesting affects the neck thickness of bulb, thin neck of bulb protect from atmospheric high temperature and high humidity and ultimately promotes the higher recovery of *onion* bulb during storage (Vitnor 2017) [8]. Curing methods did not exert any significant effect on yield and yield attributes in onion crop. However, minimum neck thickness of bulb (0.94 cm) was recorded with bulbs cured under field followed by poly tunnel curing (0.96 cm).Maximum total soluble solids (10.45%) was registered in bulbs cured under poly tunnel method. However, sulphur and allyl propyl disulphide content in bulbs and uniformity of bulb size were non-significantly influenced with curing methods. The increase in total soluble solids might be because of conversion of polysaccharides into soluble forms of sugars by Nabi *et al*. (2013) [17], Kaynas *et al.* (1995) [21], Pandey *et al.* (1992) [19] and Pandey *et al.* (1993) [18] in onion.

Table 2: Effects of nutrients, plant growth regulators and curing on yield and yield attributes in onion

Treatments	ABW	NT(cm)	PQ(cm)	EQ(cm)	TBY(kg/plot)	TBY(q/ha)	MBY(kg/plot)	MBY(q/ha)
Nutrients (kg/ha)								
N_1	56.58	1.08	3.74	4.28	19.84	317.37	16.46	271.80
N_2	69.45	1.02	4.45	5.14	24.14	382.79	20.16	333.31
N_3	73.96	0.96	4.83	5.62	26.52	408.61	22.39	373.93
N_4	76.26	0.78	4.99	5.79	27.77	425.83	23.22	386.36
S.Em+	0.77	0.01	0.05	0.06	0.34	4.47	0.24	4.35
CD (P=0.05)	2.16	0.03	0.15	0.16	0.95	12.46	0.67	12.13
Nutrient and plant growth regulators								
G_1	64.50	1.00	4.35	4.91	22.96	353.95	18.62	306.11
G_2	67.62	0.97	4.42	5.12	24.04	375.75	20.01	327.09
G_3	70.98	0.95	4.54	5.30	25.27	395.89	21.46	359.92
G_4	73.16	0.92	4.70	5.51	26.01	409.01	22.15	372.28
S.Em+	0.77	0.01	0.05	0.06	0.34	4.47	0.24	4.35
CD (P=0.05)	2.16	0.03	0.15	0.16	0.95	12.46	0.67	12.13
Curing								
C_1	68.92	0.94	4.49	5.18	24.59	381.56	20.49	340.02
C_2	69.65	0.99	4.54	5.28	24.70	390.01	20.77	346.65
C_3	68.62	0.96	4.47	5.17	24.42	379.38	20.42	337.39
S.Em+	0.67	0.01	0.05	0.05	0.30	3.87	0.21	3.77
CD (P=0.05)	NS	0.03	NS	NS	NS	NS	NS	NS

Table 3: Effect of nutrients, plant growth regulators and curing quality attributes in onion

Treatments	TSS (%)	SCB (%)	APDS(mg/g)	UBS (%)
Nutrients				
N_1	9.54	0.562	5.51	75.35
N_2	10.16	0.661	6.49	78.31
N_3	10.78	0.699	7.41	83.99
N_4	10.86	0.748	8.50	85.10
S.Em+	0.05	0.009	0.06	0.35
CD (P=0.05)	0.15	0.026	0.17	0.99
Nutrients and plant growth regulators				
G_1	9.57	0.581	6.00	77.75
G_2	10.18	0.648	6.58	78.72
G_3	10.74	0.706	7.54	82.24
G_4	10.84	0.735	7.79	84.03
S.Em+	0.05	0.009	0.06	0.35
CD (P=0.05)	0.15	0.026	0.17	0.99
Curing				
C_1	10.31	0.658	6.97	80.74
C_2	10.24	0.668	6.94	80.73
C_3	10.45	0.677	7.03	80.58
S.Em+	0.05	0.008	0.05	0.31
CD (P=0.05)	0.13	NS	NS	NS

Conclusion

On the basis of the results obtained in the present investigation, it may be concluded that application of NPKSB and mepiquat chloride along with 60% shade curing may be considered as best treatment in terms of yield and quality of onion.

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