International Journal of Plant & Soil Science

22(2): 1-11, 2018; Article no.IJPSS.39257
ISSN: 2320-7035

Chlorophyll Content, Dry Matter Accumulation, Marketable Bulb Yield, Quality and Post Harvest Nutrients Status of Soil as Affected with N Levels and Varieties in Kharif Onion (*Allium cepa* L.)

Sourav Gupta[1], S. S. Kushwah[1*] and S. N. Mishra[2]

[1]Department of Vegetable Science, College of Horticulture, Mandsaur (MP) – 458002, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalay, Gwalior (MP), India.
[2]Department of Soil Science and Agricultural Chemistry, College of Horticulture, Mandsaur (MP) – 458002, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalay, Gwalior (MP), India.

Authors' contributions

Author SG took the observations, performed the statistical analysis, wrote the first draft of the manuscript and author SSK designed the study, wrote the protocol, checked and corrected the manuscript and author SNM helped and guided in analytical work. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2018/39257
Editor(s):
(1) Alejandro Hurtado Salazar, Professor, Departamento de Produccion Agropecuaria, Universidad de Caldas, Colombia.
(2) Davide Neri, Professor, Polytechnic University of Marche - Via Brecce White, Ancona, Italy.
(3) L. S. Ayeni, Adeyemi College of Education, Ondo State, Nigeria.
Reviewers:
(1) Ade Onanuga, Dalhousie University, Canada.
(2) Ir. H. Fadly Hairannoor Yusran, Lambung Mangkurat University, Indonesia.
Complete Peer review History: http://www.sciencedomain.org/review-history/23844

Original Research Article

Received 7th January 2018
Accepted 21st March 2018
Published 27th March 2018

ABSTRACT

The present experiment was conducted with the objectives: (i) To evaluate the performance of onion varieties (ii) To study the effect of N levels (iii) To find out the interactive effect of varieties and N levels on chlorophyll content, dry matter accumulation, marketable bulb yield, quality and post-harvest available NPK content in soil. Field experiment was conducted during kharif 2011-12 at Research field, Department of Vegetable Science, College of Horticulture, Mandsaur a campus of Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (Madhya Pradesh), India. Fifteen treatment combinations comprising of three varieties (V_1 - Agrifound Dark Red, V_2 - Bhima Super, V_3 - Bhima Red) and five N levels (N_1- 0 kg ha^{-1}, N_2 - 60 kg ha^{-1}, N_3 - 90 kg ha^{-1}, N_4 - 120 kg ha^{-1} and N_5 - 150 kg ha^{-1}) were laid in factorial randomized block design with three replications. Uniform

**Corresponding author: E-mail: kushwahhort@gmail.com;*

doses of P (80 kg ha^{-1}) and K (60 kg ha^{-1}) were applied in each plot of the experiment. N doses (0, 60, 90, 120 and 150 kg ha^{-1}) were applied to the plots as per the treatment. The sources of nutrients viz., N, P and K were Urea, Single Superphosphate and Muriate of Potash, respectively. Half dose of N and whole dose of P and K were applied as basal dose before transplanting of seedlings. While the remaining half dose of N was applied in 2 equal split doses, first at 30 and second at 45 days after transplanting. The findings of the experiment revealed significant effect of varieties and N levels on chlorophyll content in leaves, dry matter accumulation, marketable bulb yield and pyruvic acid content in bulb and post-harvest nutrients status of soil and NPK content in plant. However, interactive effect of varieties and nitrogen levels was non-significant on marketable bulb yield, post-harvest available K content in soil. Highest chlorophyll content, dry weight of bulb and marketable bulb yield were recorded with Agrifound Dark Red. Variety Bhima Super had highest pyruvic acid content and lowest number of doubles. Post-harvest analysis of plant showed highest NPK content with Agrifound Dark Red. Post-harvest analysis of soil indicated highest available NPK under Bhima Super. Among N levels, highest chlorophyll content, dry weight of bulb, number of doubles, marketable bulb yield, pyruvic acid content in bulb and NPK content in plant were found with application of 150 kg N ha^{-1}. Highest available N in soil was determined with 150 kg N ha^{-1}. Highest P and K were found with 0 kg N ha^{-1}.

Keywords: Kharif onion; varieties; N; chlorophyll; dry matter; bulb yield; NPK content; soil; plant.

1. INTRODUCTION

Onion (*Allium cepa* L.) is an important vegetable crop. It belongs to the family alliaceae. The word “onion” is derived from Latin which means “large pearl”. It is also known as “Queen of Kitchen” [1]. The onion has a distinctive flavour. It is used as spice, condiment and vegetable for wide varieties of dishes. Its green leaves, immature and mature bulbs are either eaten raw or used in preparation of vegetable. There are many processed forms of onion *e.g.* flakes, powder, paste, crush, chutney and pickles. The pungency in onion is due to the presence of volatile compound allylpropyl disulphide.

Onion is a highly nutrient responsive crop. N is an essential element in all living systems and a major component of protein and chlorophyll. It becomes a limiting nutrient for higher plant growth and yield especially in low organic carbon soils. It has been reported that nitrate frequently play a controlling role in plant developmental processes, particularly in those, like onion bulbing, which involve the formation of dormant structures and an increase in soluble carbohydrate to N ratio. High levels of N nutrition prevent or delay onion bulb initiation under photoperiods which are marginal for bulb development whereas, under longer photoperiods, there is no effect of N supply. The ratio of bulb weight relative to leaf blade increases as the N level in the soil decrease [2]. Proper fertility is important in onion production. Onions require substantial amounts of nutrients. Based on a yield of 36 ton of bulbs, the plants remove about 124, 22.5 and 135.5 kg of N, P and K per hectare, respectively [3]. N being the constituent of chlorophyll develops rapid rate of growth which in turn increase the size of bulbs. However, both the deficient as well as over doses have proved to be fatal [1].

Since little information is available about rainy season onions and their N requirement. Therefore, it is an imperative to find out suitable varieties and dose of N for successful cultivation of onion during kharif season. Keeping these facts in view, the present experiment was conducted with the objectives: (i) To evaluate the performance of onion varieties (ii) To study the effect of N levels (iii) To find out the interactive effect of varieties and N levels on chlorophyll content, dry matter accumulation, marketable bulb yield, quality and post-harvest available NPK content in soil.

2. MATERIALS AND METHODS

A field investigation was carried out during kharif 2011-12 at Research field, Department of Vegetable Science, College of Horticulture, Mandsaur (Madhya Pradesh), India. Mandsaur is located in western part of Madhya Pradesh, between latitude of $23^{0}45'$ to $24^{0}13'$ North and longitude of $74^{0}44'$ to $75^{0}18'$ East at an altitude of 435.20 m above mean sea level. Weather parameters recorded during the experiment period have been presented in Table 1.The treatment combinations comprising of three varieties (V_1 - Agrifound Dark Red, V_2 - Bhima Super, V_3 - Bhima Red) and five N levels (N_1- 0 kg ha^{-1}, N_2 - 60 kg ha^{-1}, N_3 - 90 kg ha^{-1}, N_4 - 120 kg ha^{-1} and N_5 - 150 $kgha^{-1}$) were replicated thrice in factorial randomized block design. The soil of the experimental field was light alluvial having sandy loam texture, 7.5 pH, 0.18 dSm^{-1} electrical conductivity, 154.27 kg ha^{-1} available N, 5.45 kg ha^{-1} available P, 347 kg ha^{-1} available K and 11.17 kg ha^{-1} S estimated with turbidimetric method [4]. About six weeks old seedlings treated with fungicides were transplanted at distance of 15 cm × 10 cm. Date of seed sowing was 22nd July, 2011, Seedlings were transplanted on 10th September, 2011. Uniform doses of P (80 kg ha^{-1}) and K (60 kg ha^{-1}) were applied in each plot of the experiment. N doses (0, 60, 90, 120 and 150 kg ha^{-1}) were applied to the plots as per the treatment. The sources of nutrients viz., N, P and K were Urea, Single Superphosphate and Muriate of Potash, respectively. Half dose of N and whole dose of P and K were applied as basal dose before transplanting of seedlings. While the remaining half dose of N was applied in two equal split doses, first at 30 and second at 45 days after transplanting. The bulbs were harvested on January 10, 2012 when 75% tops started falling over. The tops were removed two days after field curing leaving 2.5 cm top only with the bulb. Observations were recorded on chlorophyll content (mg g^{-1} fresh weight of leaf) at 30, 60 and 75 days after transplanting, dry weight of bulb (g) 30, 60 and 75 days after transplanting and at harvest stage, marketable bulb yield, number of doubles (percentage), pyruvic acid content, NPK content in plant and post-harvest available NPK in soil. The chlorophyll content in leaves was determined as per the procedure described by Thimmaiah [5] and expressed as mg g^{-1}. The pyruvic acid content in onion bulbs was determined by the method of Anthon and Barrett [6] and expressed as µ moles per gram fresh weight. N content in plant was estimated by Kjeldahl's method [7]; P in wet digested samples by ammonium molybdate method [8] and K by flame photometer [9]. The available N in soil was determined with rapid titration method [10]. The available P was estimated with Olson's extraction method [11] and available K was determined with Flame photometer [12]. The

Table 1. Meteorological parameters recorded during the period (6th July 2011 to 14th January 2012) of experiment

SM week no.	Average weekly temperature		Relative humidity (%)	Weekly rainfall (mm)
	Min. (^{0}C)	Max. (^{0}C)		
29	26.60	36.20	69.57	11.50
30	26.22	28.57	78.42	49.63
31	24.41	29.68	86.57	27.66
32	22.42	28.24	86.14	38.30
33	23.01	28.14	76.85	05.66
34	25.22	30.87	75.42	16.00
35	23.61	32.13	74.57	19.31
36	23.88	31.84	75.20	13.30
37	23.70	29.88	73.14	Nil
38	24.95	30.82	66.85	Nil
39	24.18	33.27	63.14	Nil
40	22.97	34.38	65.28	Nil
41	20.91	33.64	71.28	Nil
42	25.07	33.75	67.00	Nil
43	23.40	33.86	65.66	Nil
44	23.48	33.62	66.71	Nil
45	23.21	33.40	59.42	Nil
46	18.38	33.18	59.00	Nil
47	19.52	32.07	57.75	Nil
48	16.85	31.55	56.00	Nil
49	20.07	29.95	58.00	Nil
50	7.67	25.20	51.57	Nil
51	7.40	31.14	55.85	Nil
52	8.31	31.77	67.00	Nil
01	6.10	23.77	63.14	Nil
02	6.15	24.98	67.85	Nil

Source: Meteorological observatory of the College of Horticulture, Mandsaur (M.P.)

data were analysed statistically as per procedure suggested by Panse and Sukhatme [13].

3. RESULTS AND DISCUSSION

3.1 Chlorophyll Content

Chlorophyll content in leaves was recorded at 30, 60 and 75 days after transplanting. The findings (Table 2) revealed significant influence of varieties at all the stages of study. In general, a linear increase in chlorophyll content was observed up to 75 days after transplanting. Highest chlorophyll content was determined with V_1 (Agrifound Dark Red), which was significantly superior to other varieties at all the stages. Lowest chlorophyll content was observed in case of V_3 (Bhima Red). The variation in chlorophyll content in leaves of different variety may be ascribed to their genetic makeup. These findings are corroborated with those of Srivastava et al. [14].

N application imposed significant influence on chlorophyll content in leaves at all the stages. Maximum chlorophyll content was determined with N dose of N_5 (150 kg N ha^{-1}), which was followed by N_4 (120 kg ha^{-1} N), N_3 (90 kg ha^{-1} N) and N_2 (60 kg ha^{-1} N). Minimum chlorophyll content in leaves was found under N_1 (0 kg ha^{-1} N). The difference between N_4 and N_5 at 60 DAT and 75 DAT was non-significant. N is a structural component of chlorophyll therefore increased availability might have enhanced the synthesis of chlorophyll. Lee et al. [15] and Singh et al. [16] also found increase in chlorophyll content with higher N doses.

Combined effect of varieties and N had significant effect on chlorophyll content in leaves at all the stages. Maximum chlorophyll content was observed under V_1N_5 (Agrifound Dark Red with 150 kg N ha^{-1}), which was significantly superior to other combinations and followed by V_2N_5 (Bhima super with 150 kg ha^{-1} N) and V_3N_5 (Bhima Red with 150 kg ha^{-1} N) both having equal values. At 60 days after transplanting maximum chlorophyll content was found under V_1N_5 (Agrifound Dark Red with 150 kg ha^{-1}) followed by V_1N_4, V_2N_5 (Bhima super with 150 kg ha^{-1}), V_2N_4 and V_1N_3 with non-significant difference. At 75 days after transplanting, V_1N_5 (Agrifound Dark Red with 150 kg N ha^{-1}) recorded maximum chlorophyll content in leaves. Minimum chlorophyll content in leaves, at 75 days after transplanting, was recorded under V_1N_1 (Agrifound Dark Red with 0 kg ha^{-1} N). These findings are in line with those reported by Hokmalipour and Darbandi (17) in maize.

3.2 Dry Weight of Bulb

There was increase in dry weight of bulb up to harvesting stage under all the varieties. Maximum dry weight of bulb was observed with V_1 (Agrifound Dark Red), which was followed by V_2 (Bhima Super) at all the stages. Lowest dry weight of bulb was recorded in variety V_3 (Bhima Red). Higher leaf area might have resulted in more photosynthesis and accumulation of photosynthates in plant and consequently more dry weight of shoot and bulbs. These findings are in line with Kimani et al. [18].

Dry weight of bulb registered significant increase with each increasing dose of N at all the growth stages. Maximum dry weight of bulb was recorded with application of N_5 (150 kg N ha^{-1}) which was significantly superior over N_4 (120 kg ha^{-1} N), N_3 (90 kg ha^{-1} N) and N_2 (60 kgha^{-1} N) at all the growth stages i.e. 30, 60, 75 days after transplanting and at harvesting stage. Minimum dry weight of bulb was recorded in N_1 (0 kg ha^{-1}) at all the stages. The increment in dry weight of bulb due to increased N levels may be attributed to the pronounced role of N in plant metabolism. N is a constituent of proteins, enzymes, hormones, vitamins and chlorophyll which might have resulted in more photosynthesis, accumulation and translocation of food material to bulbs which in turn in more dry weight of bulbs. These results are in agreement with Dilruba et al. [19] and Nasreen et al. [20] and El-Tantawy and El-Beik [21].

Dry weight of bulb reflected significant influence of combined effect of varieties and N at 30, 60, 75 DAT and at harvesting stages. In general, there was increase in dry weight of bulb under each variety with more N at all the stages. Maximum dry weight of bulb was recorded under V_1N_5 (Agrifound Dark Red with 150 kg N ha^{-1}) followed by V_2N_5 (Bhima Super with 150 kg ha^{-1} N) at both 30 and 60 days after transplanting. Whereas at 75 DAT and at harvesting stage, V_1N_5 (Agrifound Dark Red with 150 kg ha^{-1} N) was followed by V_1N_4. V_3N_1 (Bhima Red with 0 kg ha^{-1} N) recorded minimum dry weight of bulb at 30, 60 days after transplanting and at harvesting stages. At 75 DAT minimum dry weight of bulb was found under V_1N_1.

Table 2. Effect of varieties, N and their interaction on chlorophyll content and dry weight of bulb (g) in kharif onion

Treatment	Chlorophyll content (mg g^{-1} fresh leaf weight)			Dry weight of bulb (g)			
	30 DAT	60 DAT	75 DAT	30 DAT	60 DAT	75 DAT	At harvesting
Varieties (V)							
V_1	0.91	1.12	1.22	0.44	1.80	4.97	13.30
V_2	0.89	1.07	1.15	0.33	1.53	4.74	10.46
V_3	0.87	1.03	1.10	0.32	1.36	4.84	9.33
S.Em ±	**0.01**	**0.02**	**0.02**	**0.01**	**0.06**	**0.12**	**0.23**
CD at 5 %	**0.02**	**0.05**	**0.05**	**0.03**	**0.17**	**0.31**	**0.66**
N levels (N)							
N_1	0.43	0.60	0.70	0.20	0.96	3.40	7.67
N_2	0.74	0.89	1.00	0.25	1.26	4.22	8.83
N_3	0.86	1.16	1.27	0.31	1.45	4.70	10.78
N_4	1.20	1.36	1.41	0.46	1.82	5.30	13.22
N_5	1.24	1.37	1.44	0.62	2.37	6.04	14.67
S.Em ±	**0.01**	**0.02**	**0.02**	**0.02**	**0.07**	**0.14**	**0.29**
CD at 5 %	**0.03**	**0.06**	**0.06**	**0.04**	**0.22**	**0.40**	**0.85**
Interaction (V x N)							
$V_1 N_1$	0.44	0.58	0.66	0.24	1.14	2.71	9.33
$V_1 N_2$	0.80	0.88	1.11	0.29	1.41	4.23	10.00
$V_1 N_3$	0.89	1.34	1.39	0.40	1.55	5.09	13.33
V_1N_4	1.17	1.40	1.45	0.59	1.93	5.64	16.67
V_1N_5	1.29	1.41	1.51	0.69	2.99	7.18	17.17
V_2N_1	0.45	0.59	0.69	0.19	0.87	3.98	8.33
V_2N_2	0.75	0.93	0.94	0.25	1.18	4.55	9.33
V_2N_3	0.86	1.06	1.23	0.26	1.46	4.70	10.00
V_2N_4	1.21	1.38	1.46	0.35	1.97	5.07	11.83
V_2N_5	1.22	1.39	1.47	0.62	2.22	5.40	12.83
V_3N_1	0.41	0.63	0.75	0.17	0.88	3.52	5.33
V_3N_2	0.67	0.85	0.94	0.22	1.19	3.87	7.17
V_3N_3	0.85	1.07	1.18	0.26	1.32	4.31	9.00
V_3N_4	1.21	1.30	1.32	0.43	1.56	5.19	11.17
V_3N_5	1.22	1.31	1.34	0.54	1.90	5.54	14.00
S.Em ±	**0.02**	**0.04**	**0.04**	**0.03**	**0.13**	**0.24**	**0.51**
CD at 5 %	**0.05**	**0.10**	**0.11**	**0.08**	**0.38**	**0.69**	**1.48**

3.3 Number of Doubles (%)

Number of doubles (%) was recorded after harvesting. The data presented in Table 3 indicated significant influence of varieties, N and their combinations on number of doubles as expressed in percentage.

Amongst the varieties, maximum number of doubles was recorded in case of V_3 (Bhima Red) which was followed by V_1 (Agrifound Dark Red). Minimum number of doubles was recorded in V_2 (Bhima Super) at harvest.

N showed significant influence on number of doubles. Highest number of doubles was recorded with application of N_5 (150 kg ha^{-1} N) which was followed by N_4 (120 kg ha^{-1} N), N_3 (90 kg N ha^{-1}) and N_2 (60 kg ha^{-1} N) in descending order. Minimum number of double bulbs was observed with N_1 (0 kg ha^{-1} N) N. Though the difference between N_3 and N_2 was non-significant. These findings are in agreement to those of Singh and Singh [22].

Combined effect of varieties and N indicated significant influence on number of doubles at harvesting. Maximum number of doubles (%) was recorded under V_3N_5 (Bhima Red with 150 kg ha^{-1} N), which was followed by V_3N_4 (Bhima Red with 120 kg ha^{-1} N), V_1N_5 (Agrifound Dark Red with 150 kg ha^{-1} N) and V_2N_5 (Bhima Super with 150 kg ha^{-1} N). Minimum number of doubles (%) was recorded under V_2N_1 (Bhima Super 0 kg ha^{-1} N).

Table 3. Effect of varieties, N and their interaction on number of doubles percentage of kharif onion

N levels	Varieties			Mean
	V_1	V_2	V_3	
N_1	0.33	0.31	0.33	0.33
N_2	0.56	0.44	0.56	0.52
N_3	0.67	0.48	0.58	0.57
N_4	0.78	0.69	1.11	0.86
N_5	1.00	0.95	1.44	1.13
Mean	0.67	0.57	0.80	

Treatments	S.Em±	CD at $_{5\%}$
N levels	0.02	0.07
Varieties	0.02	0.05
Interaction	0.04	0.12

3.4 Yield of Marketable Bulbs (q ha^{-1})

Yield of marketable bulbs was recorded after harvesting. The data presented in Table 4 recorded significant influence of varieties and nitrogen after harvesting.

Table 4. Effect of varieties, N and their interaction on yield of marketable bulb (qha^{-1}) of kharif onion

N levels	Varieties			Mean
	V_1	V_2	V_3	
N_1	221.22	219.48	188.73	209.81
N_2	250.26	241.67	221.87	237.93
N_3	310.00	271.67	265.00	282.22
N_4	368.33	315.00	284.00	322.44
N_5	412.00	360.67	318.67	363.78
Mean	312.36	281.69	255.65	

Treatments	S.Em±	CD at $_{5\%}$
N levels	11.28	32.70
Varieties	8.75	25.33
Interaction	19.55	NS

Highest yield of marketable bulbs was recorded with V_1 (Agrifound Dark Red), which was followed by V_2 (Bhima Super) with significant difference. Minimum yield of marketable bulbs was recorded in variety V_3 (Bhima Red). Genetic factors affect the variability of many traits marking differences among cultivars (Sekara et al. [23]).

N exhibited significant effect on yield of marketable bulbs. There was significant increase in marketable bulb yield with each incremental dose of N. Highest yield of marketable bulbs was recorded with application of N_5 (150 kg ha^{-1} N) which was followed by N_4 (120 kg ha^{-1} N), N_3 (90 kg ha^{-1} N), N_2 (60 kg ha^{-1} N) and N_1 (0 kg ha^{-1} N) in descending order with significant difference. However, marketable bulb yield under N_1 and N_2 was at par. The increment in marketable yield due to higher N doses could be attributed to increase in chlorophyll content and rising photosynthesis production which associated with increment in bulb size and single bulb weight (Khan et al. [24] and Nasreen et al. [20]).

Combined effect of varieties and N imposed non-significant influence on yield of marketable bulbs. Though, numerically, maximum yield of marketable bulbs was observed under V_1N_5 (Agrifound Dark Red with 150 kg ha^{-1} N), which was followed by V_1N_4, V_2N_5 (Bhima Super with 150 kg ha^{-1} N) and V_3N_5 (Bhima Red with 150 kg ha^{-1} N). Whereas V_3N_1 (Bhima Red with 0 kg ha^{-1} N) recorded minimum yield of marketable bulbs. This might be due to the well utilization of N fertilizer in metabolism by all the varieties.

3.5 Pyruvic Acid (mg $100g^{-1}$)

Pyruvic acid in bulbs was recorded after harvesting. The data presented in Table 5 revealed significant influence of varieties, N and combined effect of varieties and N.

Table 5. Effect of varieties, N and their interaction on pyruvic acid content in kharif onion

N levels	Varieties			Mean
	V_1	V_2	V_3	
N_1	20.67	24.07	21.12	21.95
N_2	22.23	28.94	25.87	25.68
N_3	37.47	31.20	36.27	34.98
N_4	39.00	42.67	40.90	40.86
N_5	40.67	42.43	43.00	42.03
MEAN	32.00	33.86	33.43	

Treatments	S.Em±	CD at $_{5\%}$
N levels	0.53	1.53
Varieties	0.41	1.19
Interaction	0.92	2.65

Among the varieties, maximum pyruvic acid in bulbs was determined in case of V_2 (Bhima Super) which was followed by V_3 and V_1. The difference between V_2 and V_3 was non-significant. Lowest pyruvic acid in bulbs was observed under V_1 (Agrifound Dark Red), which was significantly lower than V_2 and V_3. Significant differences in pyruvic acid content among onion varieties have been also reported by Bajaj et al. [25], Dhumal et al. [26] and Lee et al. [27].

There was increase in pyruvic acid with increasing dose of N. N had significant influence on pyruvic acid in bulbs. Highest pyruvic acid content was determined with application of N_5 (150 kg ha^{-1} N) which was at par to N_4 (120 kg ha^{-1} N), but significantly higher over N_3 (90 kg ha^{-1} N) and N2 (60 kg ha^{-1} N). Minimum pyruvic acid content in bulbs was found under N_1 (0 kg ha^{-1} N).These findings are in line with Coolong and Randle (28).

Combined effect of varieties and N had significant effect on pyruvic acid in bulbs. Maximum pyruvic acid in bulbs was observed under V_3N_5 (Bhima Red with 150 kg ha^{-1} N), which was followed by V_2N_4 (Bhima Super with 120 kg ha^{-1} N), V_2N_5, V_3N_4 and V_1N_5 (Agrifound Dark Red with 150 kg ha^{-1} N) with non-significant difference. The combination V_1N_1 (Agrifound Dark Red with 0 kg ha^{-1} N) recorded minimum pyruvic acid in bulbs. These results are in agreement with McCallum et al. (29).

3.6 Post-harvest NPK Content in Plant

The findings of the experiment (Table 6) revealed significant influence of varieties on N, P and K content in plant. Maximum N content was found in case of variety V_1 (Agrifound Dark Red) which was significantly superior over other varieties. It was followed by V_2 (Bhima Super) and minimum N content was determined with V_3 (Bhima Red). Maximum P content was recorded in case of variety V_1 (Agrifound Dark Red) which was significantly superior over other varieties. It was followed by V_2 (Bhima Super) and minimum P content was determined with V_3 (Bhima Red). Highest K content was noted in case of variety V_1 (Agrifound Dark Red) which was significantly superior over other varieties. It was followed by V_2 (Bhima Super) and minimum K content was determined with V_3 (Bhima Red). Different nutrient absorption and assimilation capacity of varieties might be the reason for these findings.

N had significant influence on N content in plant. Highest N content in plant was determined with application of N_5 (150 kg ha^{-1} N) which was followed by N_4 (120 kg ha^{-1} N), N_3 (90 kg ha^{-1} N) and N_2 (60 kg ha^{-1} N). Minimum N content in plant was found under N_1 (0 kg ha^{-1} N). N had significant influence on P content in plant after harvest. Higher doses of N application might have increased the availability of N to the plants thereby increase in absorption and assimilation. These findings are corroborated with those reported by Nasreen et al. [20], Vachhani and Patel [30] and Aswani et al. [31]. Highest P content in plant was determined with application of N_5 (150 kg ha^{-1} N) which was followed by N_4 (120 kg ha^{-1} N), N_3 (90 kg ha^{-1} N) and N_2 (60 kg ha^{-1} N). Minimum P content in plant was found under N_1 (0 kg ha^{-1} N). All the N doses differed significantly with each other. Similar results were also reported by Patel and Vachhani [32] and Neeraja et al. [33]. N had significant influence on K content in plant after harvest. Highest K content in plant was determined with application of N_5 (150 kg ha^{-1} N) which was followed by N_4 (120 kg ha^{-1} N), N_3 (90 kg ha^{-1} N) and N_2 (60 kg ha^{-1} N). Minimum K content in plant was found under N_1 (0 kg ha^{-1} N). All the N levels differed significantly with each other. These findings are in line with Patel and Vachhani [32], Boyhan et al. (34).

Table 6. Effect of varieties, N and their interaction on NPK content (%) in plant after harvesting of onion

Treatment	N	P	K
Varieties (V)			
V_1	0.227	0.140	0.688
V_2	0.217	0.134	0.622
V_3	0.202	0.130	0.598
S.Em ±	**0.002**	**0.001**	**0.006**
CD at 5 %	**0.006**	**0.003**	**0.017**
N levels (N)			
N_1	0.153	0.119	0.469
N_2	0.179	0.128	0.500
N_3	0.213	0.136	0.621
N_4	0.257	0.143	0.688
N_5	0.277	0.151	0.903
S.Em ±	**0.002**	**0.001**	**0.008**
CD at 5 %	**0.008**	**0.004**	**0.022**
Interaction (VxN)			
$V_1 N_1$	0.147	0.120	0.490
$V_1 N_2$	0.180	0.140	0.520
$V_1 N_3$	0.250	0.141	0.645
V_1N_4	0.273	0.146	0.735
V_1N_5	0.287	0.156	1.050
V_2N_1	0.153	0.119	0.473
V_2N_2	0.190	0.120	0.497
V_2N_3	0.200	0.140	0.630
V_2N_4	0.253	0.142	0.672
V_2N_5	0.290	0.149	0.841
V_3N_1	0.160	0.117	0.445
V_3N_2	0.167	0.123	0.483
V_3N_3	0.190	0.126	0.587
V_3N_4	0.243	0.140	0.658
V_3N_5	0.253	0.147	0.817
S.Em ±	**0.005**	**0.002**	**0.013**
CD at 5 %	**0.014**	**0.007**	**0.040**

Table 7. Effect of varieties, N and their interaction on available NPK (kg ha^{-1}) in soil after harvesting of onion

Treatment	N	P	K
Varieties (V)			
V_1	106.26	10.02	318.71
V_2	105.35	13.86	328.83
V_3	114.01	17.98	335.72
S.Em ±	**1.00**	**0.16**	**3.26**
CD at 5 %	**2.91**	**0.47**	**9.47**
N levels (N)			
N_1	61.08	20.78	346.64
N_2	92.85	17.02	336.07
N_3	110.42	13.19	324.13
N_4	137.10	10.09	318.22
N_5	141.28	8.73	313.73
S.Em ±	**1.29**	**0.21**	**4.22**
CD at 5 %	**3.76**	**0.60**	**12.22**
Interaction (VxN)			
$V_1 N_1$	59.00	19.36	342.33
$V_1 N_2$	93.51	13.51	328.57
$V_1 N_3$	102.62	8.54	314.17
V_1N_4	135.38	4.83	307.50
V_1N_5	140.83	3.87	301.01
V_2N_1	60.00	17.42	346.30
V_2N_2	88.17	16.45	334.13
V_2N_3	100.11	13.10	326.17
V_2N_4	136.33	12.47	320.60
V_2N_5	142.17	9.91	316.97
V_3N_1	64.23	25.55	351.30
V_3N_2	96.88	21.09	345.51
V_3N_3	128.52	17.93	332.07
V_3N_4	139.58	12.96	326.57
V_3N_5	140.83	12.40	323.20
S.Em ±	**2.24**	**0.36**	**7.31**
CD at 5 %	**6.51**	**1.04**	**NS**

Combined effect of varieties and N levels had significant influence on N, P and K content in plant after harvesting. Highest N content in plant was determined with application of V_2N_5 (Bhima Super with 150 kg ha^{-1} N) which was followed by V_1N_5 (Agrifound Dark Red with 150 kg ha^{-1} N) and V_1N_4. The difference between V_2N_5 and V_1N_5 was non-significant. Minimum N content in plant was found under V_1N_1 (Agrifound Dark Red with 0 kg ha^{-1} N). Highest P content in plant was determined with application of V_1N_5 (Agrifound Dark Red with 150 kg ha^{-1} N) which was followed by V_2N_5 (Bhima Super with 150 kg ha^{-1} N) and V_3N_5 (Bhima Red with 150 kg ha^{-1} N). Minimum P content in plant was found under V_3N_1 (Bhima Red with 0 kg ha^{-1} N). Highest K content in plant was determined with application of V_1N_5 (Agrifound Dark Red with 150 kg ha^{-1} N) which was followed by V_2N_5 (Bhima Super with 150 kg ha^{-1} N) and V_3N_5 (Bhima Red with 150 kg ha^{-1} N). Minimum K content in plant was found under V_3N_1 (Bhima Red with 0 kg ha^{-1} N). These differences in nutrient content may be ascribed to the differences in the uptake of plant nutrients which depends on several factors, such as variety, crop environment, soil fertility, fertilization methods etc. These findings are in agreement with Sekara et al. [23].

3.7 Post-harvest Available N, P, K in Soil

The findings (Table 7) of the investigation revealed significant influence of varieties on available N, P and K in soil after harvesting. Among the varieties highest available N in soil was recorded in case of V_3 (Bhima Red) which was followed by V_1 (Agrifound Dark Red) with significant difference. Lowest available N in soil was determined under V_2 (Bhima Super). The difference between V_1 and V_2 was non-significant. Highest available P in soil was recorded in case of V_3 (Bhima Red) which was followed by V_2 (Bhima Super) and V_1 with significant difference. Lowest available P in soil was determined under V_1 (Agrifound Dark Red). Highest available K in soil was recorded in case of V_3 (Bhima Red) which was followed by V_2 (Bhima Super) with non-significant difference. Lowest available K in soil was determined under V_1 (Agrifound Dark Red). Higher nutrient demand promoted more nutrient absorption by the variety which might have resulted in less available nutrient in the soil.

N levels had significant influence on available N, P and K in soil after harvest. Highest available N in soil was determined with application of N_5 (150 kg ha^{-1} N) which was significantly higher as compared to N_4 (120k g ha^{-1} N), N_3 (90 kg ha^{-1} N) and N_2 (60kg ha^{-1} N). Minimum available N in soil was found under N_1 (0 kg ha^{-1} N). All the N levels differed significantly with each other. Highest available P in soil was determined with application of N_1 (0 kg ha^{-1} N) which was followed by N_2 (60kg ha^{-1} N), N_3 (90 kg ha^{-1} N) and N_4 (120 kg ha^{-1} N). Minimum available P in soil was found under N_5 (150 kg ha^{-1} N). All the N doses differed significantly with each other. Highest available K in soil was determined with application of N_1 (0 kg ha^{-1} N) which was followed by N_2 (60 kg ha^{-1} N), N_3 (90 kg ha^{-1} N) and N_4 (120 kg ha^{-1} N). Minimum available P in soil was found under N_5 (150 kg ha^{-1} N) N, which was at par to N_4 and N_3. Higher dose of N enhanced more NPK uptake by the plants which could be proved with the NPK content of the plant. Application of higher dose of N might have replenished this increased uptake of N but not of P and K consequently resulted in decreased availability of P and K in soil. These findings are in agreement with Murthy et al. [35].

Combined effect of varieties and nitrogen levels had significant influence on available N and P in soil after harvesting. Highest available N in soil was determined with application of V_2N_5 (Bhima super with 150 kg ha^{-1} N) which was followed by V_1N_5 (Agrifound Dark Red with 150 kg ha^{-1} N) and V_3N_5 (Bhima Red with 150 kg ha^{-1} N) having equal values, V_3N_4 and V_2N_4 with non-significant difference. Minimum available N in soil was found under V_1N_1 (Agrifound Dark Red with 0 kg ha^{-1} N). Highest available P in soil was found with application of V_3N_1 (Bhima Red with 0 kg ha^{-1} N) which was followed by V_3N_2 (Bhima Red with 60 kg ha^{-1} N) and V_1N_1 (Agrifound Dark Red with 0 kg ha^{-1} N). Minimum available P in soil was observed under V_1N_5 (Agrifound Dark Red with 150 kg ha^{-1} N) which was at par to V_1N_4. Combined effect of varieties and N levels had non-significant influence on available K in soil after harvesting.

4. CONCLUSION

It could be concluded from the findings of the present experiment that all the characters increased with increasing N levels except available P and K in soil. Highest chlorophyll content, dry weight of bulb, number of doubles, marketable bulb yield, pyruvic acid content in bulb and NPK content in plant were found with application of 150 kg ha^{-1} N. Highest available N in soil was determined with 150 kg ha^{-1} N. Highest P and K were found with 0 kg ha^{-1} N. Among the varieties, highest chlorophyll content, dry weight of bulb and marketable bulb yield were recorded with Agrifound Dark Red. Variety Bhima Super had highest pyruvic acid content and lowest number of doubles. Post-harvest analysis of plant showed highest NPK content with Agrifound Dark Red. Post-harvest analysis of soil indicated highest available NPK under Bhima Super. Combined effect of varieties and N levels was significant for all the parameters but marketable bulb yield and post-harvest available K content in soil. Combination of variety Agrifound Dark Red with 150 kg ha^{-1} N proved superior for chlorophyll content, dry weight of bulb and marketable bulb yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Ganie NA, Solanki RB. Quality characters of Kharif onion as affected by concentration of cycocel, intra row spacing and levels of nitrogen. Int. J. Agri. Sci. 2010;6(1):46-47.
2. Brewster JL, Butler HA. Effects of nitrogen supply on bulb development in onion. J. Exp. Bot. 1989;40(219):1155-1162.
3. Yassen AA, Khalid Kh. A. Influence of organic fertilizers on the yield, essential oil and mineral content of onion. Int. Agrophys. 2009;23:183-188.
4. Chesnin L, Yein CH. Turbidimetric determination of available sulphates. Soil Sci. Soc. Am. J. 1951;15:149-151.

5. Thimmaiah SR. Standard methods of biochemical analysis. New Delhi: Kalyani Publishers; 2004.
6. Anthon GE, Barrett DM. Modified method for the determination of pyruvic acid with dinitrophenylhydrazine in the assessment of onion pungency. J. Sci. Food Agric. 2003;83:1210-1213.
7. Jackson ML. Soil chemical analysis. New Delhi: Prentice Hall of India, Pvt. Ltd.; 1967.
8. Chapman HD, Pratt FP. Ammonium vandate-molybdate method for determination of phosphorus. In: Methods of analysis for soils, plants and water. 1st Ed. California: California University, Agriculture Division; 1961.
9. Holiday ER, Preedy JRK. The precision of a direct-reading flame photometer for the determination of sodium and potassium in biological fluids. Biochem. J. 1953;55(2): 214–220.
10. Walkley A, Black CA. An examination of the dagjareff method for determining soil organic matter and proposed modification of the chromic and titration method. Soil Sci. 1934;37:29-38.
11. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate [NaH(CO3)] U.S.D.A. Circular No. 939- Washington; 1954.
12. Ghosh AB, Bajaj IC, Hasean R, Singh D. Soil and water testing method. A lab manual. New Delhi: Division of Soil Science and Agriculture Chemistry, IARI; 1981.
13. Panse VG, Sukhatme PV. Statistical methods for agricultural workers. 4th Ed. New Delhi: ICAR Publication; 1984.
14. Srivastava RK, Dwivedi SK, Srivastava SK, Verma BK. Effect of row spacing on leaf chlorophyll content and sulphur per cent in bulb of onion (*Allium cepa* L.) varieties. Veg. Sci. 1995;22(1):59-61.
15. Lee-JT, Ha-IJ, Lee-CJ, Moon JS, Cho-YC. Effect of N, P_2O_5 and K_2O application rates and top dressing time on growth and yield of onion (*Allium cepa* L.) under spring culture in low land. Korean J. Hortic. Sci. Technol. 2003;21(4): 260-266.
16. Singh Shrawan, Yadav PK, Singh Balbir. Effect of nitrogen and potassium on growth and yield of onion (*Allium cepa* L.) cv. Pusa Red. Haryana J. Hort. Sci. 2004;33(3/4):308-309.
17. Hokmalipour S, Darbandi MH. Effects of nitrogen fertilizer on chlorophyll content and other leaf indicate in three cultivars of maize (*Zea mays* L.). World Appl. Sci. J. 2011;15(12):1780-1785.
18. Kimani PM, Kariuki JW, Peters R, Rabinowitch HD. Influence of the environment on the performance of some onion cultivars in Kenya. Afr. Crop Sci. J. 1993;1(1):15-23.
19. Dilruba S, Alam MM, Rahman MA, Hasan MF. Influence of nitrogen and potassium on yield contributing bulb traits of onion. Intl. J. Agri. Res. 2006;1(1):85-90.
20. Nasreen S, Haque MM, Hossain MA, Farid ATM. Nutrient uptake and yield of onion as influenced by nitrogen and sulphur fertilization. Bangladesh J. Agril. Res. 2007;32(3):413-420.
21. El-Tantawy EM, El-Beik AK. Relationship between growth, yield and storability of onion (*Allium cepa* L.) with fertilization of nitrogen, sulphur and copper under calcareous soil conditions. Res. J. Agric. & Biol. Sci. 2009;5(4):361-371.
22. Singh RB, Singh SB. Significance of nitrogen, phosphorus and potassium on onion (*Allium cepa* L.) raised from onion sets (bulblets). Veg. Sci. 2000;27(1):88-89.
23. Sekara A, Pokluda R, Del VL, Somma S, Caruso G. Interactions among genotype, environment and agronomic practices on production and quality of storage onion (*Allium cepa* L.) – A review. Hort. Sci. (Prague). 2017;44:21–42.
24. Khan H, Iqbal M, Ghaffoor A, Waseem K. Effect of various plant spacing and different nitrogen levels on the growth and yield of onion (*Allium cepa* L.). J. Biol. Sci. 2002;2(8):545-547.
25. Bajaj KL, Kaur Gurdeep, Singh Jarnail, Gill SPS. Chemical evaluation of some important varieties of onion (*Allium cepa* L.). Plant Foods Hum. Nutr. 1980;30(2):117-122.
26. Dhumal K, Datir S, Pandey R. Assessment of bulb pungency level in different Indian cultivars of onion. (*Allium cepa* L.). Food Chem. 2007;100(4):1328-1330.
27. Lee EJ, Yoo KS, Jifon J, Patil BS. Characterization of short day onion cultivars of 3 pungency levels with flavor precursor, free amino acid, sulfur, and sugar contents. J. Food Sci. 2009;74:C475–C480.

28. Coolong TW, Randle WM. Ammonium nitrate fertility levels influence flavour development in hydroponically grown 'Granex 33' onion. J Sci Food Agric. 2003;83:477–482.
29. McCallum John, Porter Noel, Searle Bruce, Shaw Martin, Bettjeman Bodhi, McManus Michael. Sulfur and nitrogen fertility affects flavour of field-grown onions. Plant and Soil. 2005;269:151–158.
30. Vachhini MU, Patel ZG. Effect of nitrogen, phosphorus and potash on bulb yield and quality of onion (*Allium cepa*). Indian J. Agron. 1993;38(2):333-334.
31. Aswani Gunjan, Paliwal R, Sarolia DK. Effect of nitrogen and bio-fertilizers on yield and quality of rabi onion (*Allium cepa* L.) cv. Puna Red. Agric. Sci. Digest. 2005;25(2):124-126.
32. Patel ZG, Vachhini MU. Effect of NPK fertilization on the yield and quality of onion. The Hort. J. 1994;1:75-77.
33. Neeraja G, Reddy KM, Reddy MS, Roa VP. Influence of irrigation and nitrogen levels on bulb yield, nutrient uptake and nitrogen use efficiencies in rabi onion (*Allium cepa* L.). Indian J. Agri. Sci. 2001;71(2):109-112.
34. Boyhan GE, Torrance RL, Hill CR. Effects of nitrogen, phosphorus, and potassium rates and fertilizer sources on yield and leaf nutrient status of short-day onions. Hort Science, 2007; 42(3):653–660.
35. Murthy KM Dakshina, Rao AU, Vijay D, Sridhar TV. Effect of levels of nitrogen, phosphorus and potassium on performance of rice. Indian J. Agric. Res., 2015;49(1):83-87.

© 2018 Gupta et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/23844