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RESEARCH ARTICLE

SEED TUBER YIELD, QUALITY AND STORABILITY OF POTATO VARIETIES WITH VARYING NITROGEN LEVELS IN TARAI REGION OF UTTARAKHAND

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ABSTRACT

To find out the effect of nitrogen fertilizer on tuber quality and storability of potato varieties, an experiment was conducted for two consecutive years during 2012-13 and 2013-14 at Vegetable Research Center, G.B.P.U.A. & T. Pantnagar. Two potato varieties and five nitrogen levels (0, 75, 150, 225, 300 kg N/ha) were used in the experiment as treatment. It was observed that the dry matter content (%), specific gravity (g/cm^3), TSS content (%) and reducing sugar content (mg/100 g) were higher in variety Kufri Surya than Kufri Sadabahar, while the protein content (%) was observed higher in Kufri Sadabahar (V_1) than Kufri Surya (V_2). The dry matter content was recorded highest (21.00 %) with treatment N_1 (75 kg N/ha) while, specific gravity was highest (1.06 g/cm^3) with treatment N_0 (0 kg N/ha). The TSS content (4.34 %) and Protein content (7.34 %) were maximum with treatment N_2 (150 kg N/ha), while reducing sugar content (182.60 mg/100 g dry matter) was highest with treatment N_4 (300 kg N/ha). The weight loss and sprouted tubers were recorded higher in Kufri Surya upto 60 days storage, while after 90 days storage, it was higher in Kufri Sadabahar (V_1). The number and weight of rotted tubers (6.97 % and 7.83 %, respectively) were recorded higher in Kufri Sadabahar (V_1) than Kufri Surya (V_2). The storability of potato tubers decreased with the increase in nitrogen level from N_0 to N_4. Thus, for getting higher seed size tuber yield, variety Kufri Surya with application of 150 kg N/ha is better than all other treatments and it also maintain optimum quality of tuber.

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INTRODUCTION

Potato originated in highland tropics of Andean mountains of Bolivia and Peru in South America and is believed to be introduced in India by Portuguese traders towards the beginning of 17th century (Latha *et al*., 2004). Nitrogen is the major plant nutrient without which the higher agricultural production is not possible (Reddy and Nagender, 2013). For potato production nitrogen is first limiting nutrient and greatly influences the tuber yield, quality and storability. Inadequacy of nitrogen application deceases the yield by reducing the plant growth, while, excess of nitrogen may also affect the yield by interfering with the translocation of photosynthates from tops to tubers. Over doses of nitrogen can directs dry matter storage in to aerial parts rather than tubers. Excess levels of soil nitrogen at or before tuberization can delay tuber growth, reduce yield and lower tuber specific gravity (Rahmei *et. al*., 2005). Excess N in the late growing season can delay maturity of the tubers which can adversely affect potato storability and quality (Zebarth and Rosen, 2007). Nitrogen uptake by potato crop is a function of yield potential and variety. The period of nitrogen uptake in potato plant begins about the time of rapid biomass accumulation and it is completed long before the crop reaches maturity. The maximum amount of above ground crop nitrogen is called "maximum nitrogen uptake". Nitrogen is one of main components of proteins. In abnormal conditions like over use of nitrogen fertilizer, protein production decreased and nitrogen will be stored as non-protein form (Vaezzadeh *et al*., 2012). Heavy use of nitrogen fertilizer in potato field, which combined with a shallow root system, creates high risk of nitrogen leaching losses (Neumann *et al*., 2012). Thus, maintaining high crop yields with minimum nutrient losses to the environment is a challenge to the potato producers (Ruza *et al*., 2013). A total of 90 % of potato production in India is from the Indo-Gangetic plains, where the crop is harvested from January to March before on set of long hot summer. Storage

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under ambient conditions in India plains can result in enormous losses due to shrinkage, sprouting and attack by micro-organisms (Chandra *et al*., 2014). Thus it is necessary to use suitable variety with optimum nitrogen dose for getting higher benefits from the crop produce.

MATERIALS AND METHODS

The present investigation was undertaken at Vegetable Research Centre of G.B.P.U.A. & T. Pantnagar during Rabi season of 2012-13 and 2013-14. The experiment consists of five levels of nitrogen fertilizer *viz.,* 0 (N_0), 75 (N_1), 150 (N_2), 225 (N_3) and 300 kg/ha (N_4) and two variety *viz.* Kufri Sadabahar (V_1) and Kufri Surya (V_2), which were replicated thrice in factorial randomize block design. The half of the each level nitrogen apply as basal and remaining half amount top dressed after 30 days of planting. The source of nitrogen was urea (46% N). The potato crop was de-haulmed at 90 days after planting. Rest of the agronomic package of practices was adopted as per crop requirement. After harvest, tubers were categorized according to their weight and medium size tubers (26-75 g) were taken as seed size tubers. All yield, quality and storability parameters were recorded by using seed size tuber and 10 kg seed size tubers from each treatment were kept for storage under ambient condition upto 90 days.

Specific gravity was recorded by water displacement method and Total Soluble Solids of fresh potato tuber was measured at room temperature with the help of Hand Refrectometer at 0-32 percent scale. Micro-Kjeldhal method was used to estimate protein content and reducing sugar was estimated by Nelson-Somogyi method (Sadasivam and Manickam, 1992). Tuber storability parameters were recorded upto 90 days at every 30 days interval. The observed data were then subjected to statistical analysis of variance (Sukhatme and Amble, 1995).

RESULTS AND DISCUSSION

Seed size tuber yield: Response of varieties: Varieties show significant variation for number and yield of seed size tubers of potato. The number and yield of seed size tubers was recorded higher (590.92 thousand/ha and 20.86 t/ha, respectively) with variety Kufri Surya (V_2) than Kufri Sadabahar (V_1) which gave 557.33 thousand/ha and 18.48 t/ha, respectively. It is fact that total number of tuber mainly depends on number of stolons, therefore, if potato plant have higher number of stolons with higher number of haulms ultimately resulted into higher number of tubers. Significant effects of varieties on potato yield were also recorded by Ravikant and Chadha (2009).

Response of nitrogen

An optimum level of nitrogen is responsible for increased size of potato tuber. The maximum number and yield of seed size tuber was recorded (716.47 thousand/ha and 25.34 t/ha, respectively) with treatment N_2 (150 kg N/ha) and minimum (411.13 thousand/ha and 13.16 t/ha) with treatment N_0 (0 kg/ha). It was observed from the data (table. 1) that as nitrogen level increase the number and yield of potato tubers increased 42.62 % and 48.06 %, respectively upto a level N_2 (150 kg N/ha) over N_0 (0 kg N/ha), while, beyond this it decreased 23.67 % and 27.11 %, respectively. This might be due to better availability and efficient use of this level nitrogen by the plant as a results accumulation of more food material in tubers. The decrease in total yield above 150 kg N/ha application might be due to the fact that in such conditions, vegetative growth of the areal parts can be increased and hence, prevented transferring of photosynthetically synthesis matters in to storage parts *i.e.* tuber. Kumar and Trehan (2012) reported that the yield of medium size potato tubers (25-75 g) increase with increase in nitrogen level upto application of 160 kg N/ha. These findings were also in agreement with the finding of Geofrey *et al*. (2014) and Chandra *et al*. (2015).

Table 1. Effect of varieties, nitrogen levels and their interaction on yield and quality of potato seed tubers

Treatments	Number of seed tuber (000/ ha)	Yield of seed tuber (t/ ha)	Dry matter content (%)	Specific gravity (g/cm^3)	TSS content (%)	Protein content (%)	Reducing sugar content (mg/100g)
Variety							
V_1	557.33	18.48	19.09	1.03	3.88	6.75	162.8
V_2	590.92	20.86	19.33	1.04	4.06	6.61	166.3
S.Em±	3.41	0.57	0.16	0.15	0.32	0.19	0.64
CD at 5%	10.13	1.69	NS	NS	NS	NS	1.91
Nitrogen							
N_0	411.13	13.16	19.83	1.06	3.63	5.91	144.3
N_1	622.42	20.05	21.00	1.05	4.14	6.21	154.9
N_2	716.47	25.34	19.74	1.03	4.34	7.37	164.9
N_3	561.62	20.91	18.05	1.03	4.03	7.27	176.1
N_4	546.89	18.47	17.44	1.02	3.72	6.62	182.6
S.Em±	5.39	0.90	0.25	0.24	0.51	0.30	1.02
CD at 5%	16.01	2.67	0.76	NS	0.15	0.90	3.02
Interaction (VxN)							
V_1N_0	401.19	12.82	19.06	1.06	3.51	5.82	143.8
V_1N_1	623.38	19.52	21.02	1.05	4.08	6.16	152.6
V_1N_2	694.14	24.13	20.45	1.04	4.27	7.28	162.2
V_1N_3	555.17	19.97	17.83	1.03	3.94	7.48	173.8
V_1N_4	537.54	18.11	17.09	1.02	3.61	6.99	181.5
V_2N_0	421.07	13.50	20.61	1.06	3.75	6.00	144.8
V_2N_1	621.47	20.01	20.97	1.05	4.20	6.26	157.1
V_2N_2	738.73	27.13	18.84	1.05	4.40	7.47	167.6
V_2N_3	567.63	21.86	18.26	1.03	4.11	7.07	178.3
V_2N_4	552.06	18.85	17.79	1.02	3.79	6.26	183.6
S.Em±	7.60	1.27	0.36	0.33	0.73	0.43	1.44
CD at 5%	22.65	3.78	1.06	NS	NS	NS	NS

Interaction effect

The interaction effect of variety and nitrogen was observed significant with respect to number of seed size tubers and seed tuber yield. It was observed from the data (table. 1) that the interaction of variety Kufri Surya and 150 kg N/ha (V_2N_2) gave maximum number of seed tuber (738.73 thousand/ha) and

seed tuber yield (27.13 t/ha), while it was minimum (401.19 thousand/ha and 12.82 t/ha, respectively) with treatment V_1N_0 (Kufri Sadabahar without nitrogen application). It was observed that both the varieties (Kufri Sadabahar and Kufri Surya) show 46.87 % and 50.24 % increase in mean seed tuber yield upto treatment N_2 (150 kg N/ha) over N_0 (0 kg N/ha) and thereafter a decrease of 24.95 % and 30.52 %, respectively, was recorded. These finding was in agreement with results of Barghi *et al*. (2012).

Table 2. Effect of varieties, nitrogen levels and their interaction on storability of potato tubers (%) at room storage

Treatments	Physiological weight loss of potato tubers (%)			Number of sprouted tubers (%)		Weight of sprouted tubers (%)		Number of rotted tuber (%) at 90 days after storage	Weight rotted tuber (%) at 90 days after storage
	30 Days	60 Days	90 Days	60 Days	90 Days	60 Days	90 Days		
Variety									
V_1	4.31	6.51	9.02	22.32	42.03	20.80	41.70	6.97	7.83
V_2	4.56	6.78	8.61	21.23	41.90	20.30	39.77	6.94	7.81
S.Em±	0.13	0.13	0.70	0.27	0.65	0.34	0.40	0.16	0.17
CD at 5%	NS	NS	0.21	0.81	NS	NS	NS	NS	NS
Nitrogen									
N_0	3.46	5.73	7.75	17.08	36.43	17.09	34.54	5.62	6.53
N_1	4.01	6.37	8.17	18.83	39.35	18.60	38.87	6.20	6.91
N_2	4.43	6.65	8.75	21.75	41.79	20.31	41.24	6.66	7.75
N_3	5.04	7.16	9.42	24.33	46.04	23.35	43.68	7.92	8.87
N_4	5.21	7.30	9.69	26.33	47.70	24.46	45.32	8.37	9.08
S.Em±	0.20	0.21	0.11	0.43	1.03	0.54	0.64	0.25	0.27
CD at 5%	0.59	0.61	0.33	1.29	3.06	1.59	1.89	0.76	0.81
Interaction (VxN)									
V_1N_0	3.18	5.84	8.28	17.67	37.90	16.76	36.02	5.56	6.29
V_1N_1	3.54	6.10	8.56	18.00	40.53	18.72	39.65	6.14	6.35
V_1N_2	4.36	6.60	8.95	21.00	43.21	20.81	41.72	6.61	7.22
V_1N_3	4.99	7.02	9.74	23.83	46.59	23.40	44.69	7.90	8.92
V_1N_4	5.32	7.00	9.77	25.82	48.02	24.05	46.43	8.65	9.30
V_2N_0	3.41	5.62	7.21	16.50	34.97	17.42	33.20	5.69	6.77
V_2N_1	4.49	6.64	8.02	19.67	38.18	18.47	37.95	6.26	7.48
V_2N_2	4.50	6.70	8.55	22.58	40.37	19.92	40.47	6.72	8.28
V_2N_3	5.09	7.31	9.11	24.50	45.48	23.30	42.38	7.95	8.80
V_2N_4	5.11	7.61	9.70	26.83	47.38	24.88	44.14	8.10	8.86
±SEM	0.28	0.29	0.16	0.61	1.46	0.76	0.90	0.36	0.39
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

Tuber quality

Response of varieties

Two years pooled data showed that the varieties were respond non significantly to tuber quality parameters except reducing sugar content of tuber. It was observed that tuber dry matter content (19.33 %), specific gravity (1.04 g/cm^3) and TSS content (4.06 %) higher in variety Kufri Surya (V_2) than Kufri Sadabahar (V_1). Potato protein has a high biological value, because all amino acids are present in this comparatively in larger quantities (Banu *et al*., 2007). Protein content of tuber was observed 2.07 % higher in Kufri Sadabahar (6.75 %) than Kufri Surya (6.61 %), however, the variation was recorded non significant. Reducing sugar content was recorded significantly higher in variety Kufri Surya (166.3 mg/100 g dry) than Kufri Sadabahar (162.8 mg/100 g). Sandhu *et al*. (2010) also reported significant impact of varieties on reducing sugar content of potato tuber.

Response of nitrogen

Tuber dry matter content is an important quality parameter which determines the yield of fried products and energy consumption for frying. Tuber quality characters showed significant variation to nitrogen level. The tuber dry matter content was observed maximum (21.00 %) with treatment N_1 (75 kg N/ha). Above this level of nitrogen application, the dry matter content decreased gradually and was minimum (17.44 %) with N_4 (300 kg N/ha) treatment. The reduction in tuber dry matter content may be because of increased water content to maintain cell turgor pressure against increased negative solute potential. Similar result was also reported by Singh and Lal, (2012). Specific gravity of tuber was decreased with the increase in nitrogen levels from N_0 to N_4, however the variation was observed non significant. Mean data of two years study revealed that the specific gravity of tuber was highest (1.06 g/cm^3) with treatment N_0 and lowest (1.02 g/cm^3) with treatment N_4. The decrease in specific gravity might be due to decrease in dry matter content of tuber with increasing nitrogen levels which is responsible for increased nitrogen content in potato tubers. These finding was in agreement with the finding of Zinada (2009). Maximum TSS content was recorded (4.34 %) with treatment N_2 followed by treatment N_1 and minimum (3.63 %) with treatment N_0. The TSS content of tuber was increased 16.36 % with increase in nitrogen levels upto N_2 (150 kg N/ha) over N_0 and beyond this it was decreased 14.28 % upto treatment N_4. The decrease in TSS content after a certain levels of nitrogen might be due to consistent increase in water content and turgidity of cells in tubers. Protein content of tuber was increased gradually with increasing nitrogen level upto treatment N_2 (150 kg N/ha) and above this it was decreased. Highest protein content was observed (7.37 %) with treatment N_2, which was statistically at par with treatment N_3 (7.27 %) and minimum (5.91 %) with treatment N_0. This significant effect on protein content could be related to the vital role of nitrogen in plant that associated directly and indirectly with protein synthesis (Chandra and Raghav, 2014). Reducing sugar content of tuber was increased 20.97 % with the increase in nitrogen level upto treatment N_4 over treatment N_0. It was recorded highest (182.60 mg/100 g) with highest level of nitrogen treatment *i.e.* N_4 and lowest (144.30 mg/100 g) with treatment N_0. Reducing sugars content was also found increased with increasing nitrogen levels by Banu *et al*., (2007).

Interaction effect

Interaction of varieties and nitrogen levels were significantly affect the dry matter content of tuber, while the specific gravity, TSS content, protein content and reducing sugar content of tuber shows non significant variation. The maximum dry matter content of tuber was recorded (21.02 %) with treatment V_1N_1 (Kufri Sadabahar and 75 kg N/ha), which was 18.70 % higher over minimum dry matter content which was found (17.09 %) with treatment V_1N_4 (Kufri Sadabahar and 300 kg N/ha). These results were also in agreements with the finding of Sandhu *et al*., (2010) and Kandi *et al*., (2011).

Tuber storability

Response of varieties

Varieties show non significant effect on physiological weight loss of tuber upto 60 days storage, but after 90 days storage, the variation was observed significant (table 2). At 90 days after storage, variety Kufri Sadabahar (V_1) showed 4.54 % higher physiological weight loss *i.e*. 9.02 % than Kufri Surya (V_2) having 8.61 % losses. This variation between varieties may be because of some varieties tends to loss more water (transpirational loss) and/or carbon (respirational loss) in storage compared to others. Greater weight losses can also result of higher pressure bruise potential in some varieties. These findings are also in agreement with finding of Fontes *et al*. (2010). The number and weight of sprouted tubers were recorded higher in variety Kufri Sadabahar than variety Kufri Surya, however the variation was observed non significant except number of sprouted tubers at 60 days after storage. At 60 days after storage the number of sprouted tubers was recorded higher (22.32 %) in variety Kufri Sadabahar than Kufri Surya *i.e.* 21.23 %. The different varieties show variable storability of potato tubers, this might be due to variation in dormancy period of varieties which gives information about how long the tuber will store before it initiates sprout development. The number and weight of rotted tubers was recorded higher in variety Kufri Sadabahar (6.97 % and 7.83 %, respectively) than Kufri Surya (6.94 % and 7.81 %, respectively), however the variation was found non significant.

Response of nitrogen

Storage loss of tuber was increased with increase in nitrogen level applied (Table 2). Physiological weight loss of tuber was recorded maximum at 30, 60 and 90 days after storage (5.21 %, 7.31 % and 9.69 %, respectively) with treatment N_4 and minimum (3.46 %, 5.73 % and 7.75 %, respectively) with treatment N_0. This was observed that the physiological weight loss of tubers was increase 33.59 %, 21.61 and 20.02 % at 30, 60 and 90 days after storage, respectively, as nitrogen levels increases from treatment N_0 to N_4. This increase in weight loss might be due to tuber harvested from higher nitrogen treatment content higher moisture content, which was more susceptible to shriveling and higher moisture loss during storage. This higher moisture loss might be responsible for higher physiological weight loss of potato tubers. The increase in weight loss and rottage of tubers with increase in nitrogen levels was also reported by Singh and Lal (2012). At 60 and 90 days after storage, mean number (26.33 % and 47.70 %, respectively) and weight (24.46 % and 45.32 %, respectively) of sprouted tubers was recorded highest with treatment N_4 and lowest number (17.07 % and 36.43 %, respectively) and weight (17.09 % and 34.54 %, respectively) with treatment N_0. Gautam *et al*., (2011) also observed that percentage of sprouted tubers was increased with an increase in nitrogen level. At 90 days after storage, the number (8.37 %) and weight (9.08 %) of rotted tubers were recorded maximum with treatment N_4, followed by treatment N_3 and minimum (5.62 % and 6.53 %, number and weight of rotted tubers, respectively) with treatment N_0. These results were also in agreement with finding of Reiter *et al*., (2012).

Interaction effect

The storability characters of potato tubers (*i.e*. physiological weight loss, sprouted tubers and rotted tubers) in both the varieties were decreased as nitrogen levels increase. However, interaction effect varieties and nitrogen did not show any remarkable variation in relation to storability parameters of potato tuber.

Conclusion

The storability of seed tubers was better at N_0 (0 kg N/ha) level of nitrogen application than other treatments, while different quality traits differ in their performance with application of varying nitrogen levels. Some quality traits increased with increasing nitrogen levels and other are decreased. So it is necessary to apply such a nitrogen dose which gives optimum quality and storability of seed tubers without reducing yield of seed tubers. On the basis of experimental results it was concluded that among all treatments, the variety Kufri Surya with application of 150 kg N/ha was better for seed tuber yield and it also maintain optimum quality of tuber.

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