Research Article

Response of potato genotypes to different levels of nitrogen

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Abstract

The present study was carried out to evaluate response of potato genotypes to different levels of nitrogen at fruit and vegetable nursery, Department of Horticulture, The University of Azad Jammu and Kashmir-Pakistan during the cropping season 2014. The experiment was laid out in Randomized Complete Block (RCB) Design with split plot arrangement, consisting of nitrogen levels and potato genotypes. There were five levels of nitrogen i.e. (0, 80, 100, 120 & 140 kg N ha⁻¹) and three potato genotypes viz., Ronaldo, Senna red and HZD 00-112. The data was collected for different growth and yield parameters at each and every level of nitrogen. The highest significant values for most of the traits studied were recorded at 120 kg ha⁻¹ nitrogen Genotype Ronaldo have maximum survival% age (80.44%), plant population (12.07 %), number of leaves plant⁻¹ (176.81), plant leaf area (8.36 cm²), number of branches plant⁻¹ (59.45), plant height (52.56 cm), number of tuber plant⁻¹ (8.03), tuber diameter (4.56 cm), average weight of tuber plant⁻¹ (375.07g), and yield of tuber plot⁻¹ (22.80-ton ha⁻¹). Potato variety Ronaldo has given the highest yield (27.85 tones ha⁻¹). Based on the results of the present study, it is recommended that application of nitrogen at 120 kg ha⁻¹ can enhance over all productivity of potato under prevailing environmental conditions of Rawalakot, Kashmir-Pakistan.

Keywords: Potato; Nitrogen levels; Genotype; Yield; Moisture content

Introduction

Potato (*Solanum tuberosum* L.) is the fourth most important crop after rice, wheat and maize in the world [1]. It is one of the leading exportable vegetable and important cash crops of Pakistan especially in hilly area of Azad Jammu and Kashmir. In Pakistan potato crop is grown over an area of 0.1095 million hectares with a total production of 1.8104 million tones. Average yield of potato is 16.5 tones ha⁻¹ [2]. Its growth, yield and quality largely

depend on soil and climatic condition as well as on different production practices. Available reports indicate that the yield of potato increased substantially through adequate application and judicious management of fertilizers [3].

It is mainly produced on coarse textured calcareous soils in arid land and under center pivot irrigation systems. It is widely accepted that nitrogen is the most limiting nutritional factor to crop production in arid, semiarid and desert lands. Thus, addition

of N-fertilizer to soils has become a mandatory agricultural practice in arid regions [5]. Among the plant nutrients, nitrogen is high significant for the production of potato. When nitrogen is given to the crop in suitable amount, it produced maximum yield [4]. Deficiency of nitrogen causes less growth, reduced light interception, minimize yield and early crop senescence. On the other hand, the availability of excess nitrogen can result in low yield, delay tuber formation and reduce the dry matter content of tuber [6]. Yield and quality of potato are affected by environmental conditions, variety and cultural practices [7]. Potato crop is sensitive to application and management of nitrogen, less or high amount from its normal requirement or early and late application will affect quantitative and qualitative yield of tuber [8]. Potato is a short duration, high yielding and exhaustive crop. Therefore, use of balanced fertilizers become more necessary and pre-requisite for getting better and higher yield of tuber crop.

Nitrogen application play an important role in the management of soil fertility, as its over usage may delay the maturity of plant and cause the storage of dry matter into aerial parts rather than the tubers of potato [9]. Therefore, the present study was conducted to find out the optimum level of nitrogen and suitable potato genotype for growth and yield in the agro-climatic conditions of Rawalakot, Azad Jammu and Kashmir-Pakistan.

Materials and methods

The research study was conducted at fruit and vegetable nursery, Department of Horticulture, The University of Azad Jammu and Kashmir-Pakistan during summer 2014. Experiment was laid out in two-factor factorial Randomized Complete Block (RCB) Design with split plot arrangement having three replications. The seeds of three cultivars naming (Ronaldo, Senna Red, HZD 00-112) were collected from National Agriculture Research Centre (NARC) Islamabad-Pakistan and were sown in main plots while five nitrogen levels i.e.0, 80, 100, 120 and 140 kg ha⁻¹ were assigned to subplots, size of the sub plot was 3 m². The row to row distance was 60 cm and one sub plot comprised on three rows. The basal dose of phosphorus (SSP) was applied at the rate of 80 kg ha⁻¹ at the time of planting and nitrogen (urea) was applied in split doses. Half of nitrogen was applied at the time of planting and remaining half nitrogen was applied in furrows at 40 days after planting. The well-sprouted seed tubers were planted at a depth of 5-7 cm in furrows made 30 cm apart. Intercultural operation including irrigation and earthing up was done as and when necessary. The crop was harvested after 3 months.

Soil analysis

Soil sample was randomly collected at a depth of 25 cm from different parts of the field for measuring different soil properties as shown in table 1.

Table 1. Soil analysis of experimental soil

Determination	Nitrogen (%)	Lime (%)	EC dms ⁻¹	pH	Textural class
Quantity	0.213	11.4	0.29	7.67	Silty loam

Cultural practices

Irrigation

First irrigation was applied after sowing of the tubers. Proper care was taken to avoid over flooding. The subsequent irrigation was done at weekly interval keeping in view the weather condition.

Hoeing and weeding

All the cultural practices were accomplished throughout the growth period. Manual hoeing and weeding was done when necessary.

Data collection and analysis

The data were collected on the following attributes, emergence percentage, survival percentage, plant population, number of leaves plant⁻¹, plant leaf area (cm²), maximum leaf length (cm), number of branches plant⁻¹, plant height (cm), number of tuber plant⁻¹, tuber diameter (cm), average weight of tuber plant⁻¹ (g), yield of tuber plot⁻¹ (tons ha⁻¹) and total soluble solids.

Total soluble solid

TSS were determined in a drop of potato juice using refractometer as describe by [10].

Collected data was analyzed by using MSTAT-C software. The analysis of variance (ANOVA) technique and difference among treatment means was compared by using LSD (least significant difference) test [11].

Results and discussion

Survival %age

Survival percentage was significantly affected by varieties (V) and interaction between V × N while nitrogen (N) was found non-significant (Table 2). The maximum survival percentage (80.44%) was observed in Ronaldo followed by Senna-Red (73.78%) while lowest survival percentage (71.11 %) were noted in HZD 00-112.

Ronaldo variety attained superiority on other varieties and showed highest survival percentage (93.33 %) when nitrogen was applied at 120 kg ha⁻¹ (N₄) followed by HZD 00-112 (60.00 %) when nitrogen was given at 140 kg ha⁻¹ (N₅). while Senna-Red variety was non-significant difference with each other survival rate of (68.89 %) at control (N₀). According to the results it is predicted that environmental conditions of Rawalakot is suitable for variety Ronaldo (93.33 %) which shows good survival rate as compared to varieties Senna-Red (68.89 %) and HZD 00-112 (60.00 %). It is genetic potential in varieties which utilize their own store food for survival. It is evaluated that nutrients had no effect on survival percentage. The results are in agreement

with [12] who reported that urea is essential nutrients for plant growth and survival.

Plant population (After complete germination)

Data pertaining to plant population after complete germination presented in (table 2). Plant population after complete germination significantly affected by varieties (V) and interaction between V × N were found significant difference among each other while nitrogen (N) was non-significant. Higher Plant population after germination (12.07 %) was observed in Ronaldo followed by Senna-Red (11.07 %) while minimum (10.67 %) were recorded in HZD 00-112.

The variety Ronaldo took maximum germination in numbers (14.00 %) when nitrogen was given at 120 kg ha⁻¹ (N₄). least Plant population were recorded in variety HZD 00-112 (9.00 %) by the application of nitrogen at 140 kg ha⁻¹ (N₄). Plant population was dependent upon the emergence. In variety HZD 00-112 Plant population was significantly less than varieties Ronaldo and Senna-Red. It might be due to environmental condition of Rawalakot. The results are in agreement with [13]. They reported that nutrients have no or little effect to germinate plants plot⁻¹ to utilize their own food.

Number of leaves plant⁻¹

Data regarding maximum number of leaves plant⁻¹ in different genotypes presented in (table 2) depicted non-significant for this parameter. The greater leaf production plant⁻¹ was observed in potato genotypes Ronaldo (176.81) followed by Senna-Red (147.97) leaves plant⁻¹. The least leaf production plant⁻¹ was recorded in HZD 00-112 (148.97) leaves plant⁻¹.

The results showed that mean of nitrogen had significant difference with each other. Maximum number of leaves 173.78 was attained when nitrogen was given at 80 kg ha⁻¹ N. 166.44 follow it when nitrogen was applied at 100 kg ha⁻¹ N. Minimum number of leaves was recorded 146.31 by the application of nitrogen at 120 kg ha⁻¹ N. It is evaluated from the results that maximum

number of leaves was observed when nitrogen was given at 80 kg ha⁻¹ N. This might be due to the better availability of nitrogen and the enhancing effect of nitrogen on vegetative growth by increasing cell division and cell elongation. The results are similar with [14] reported that urea is the main source for plant height and for the production of maximum number

of leaves. These results are also in agreement with those obtained by [15] and [16, 17] who reported that the increase in nitrogen application amounts up to a definite point, increases growth parameters including tuber but beyond that, reversely decreases them. Over-application of nitrogen may result in a decrease in yield.

Table 2. Shows mean values for survival percentage, no. of plant population, no. of leaves plant⁻¹, plant leaf area, leaf length and no. of branches as affected by different doses of nitrogen and genotypes of potato

Varieties	Survival %	Plant population	No. of leaves plant ⁻¹	Plant leaf area	Leaf length	No. of branches
Ronaldo	80.44a	12.07a	176.81a	8.36a	4.99b	59.45a
Senna-Red	73.78ab	11.07b	147.97a	6.63b	5.36a	52.93ab
HZD 00-112	71.11b	10.67b	148.97a	6.16b	5.12b	47.97b
LSD 0.05	5.52	0.83	NS	1.32	0.19	8.20
Nitrogen levels (kg ha⁻¹)						
0	72.59	10.89	151.91	5.85c	4.29c	35.91b
80	75.56	11.33	173.78	5.98c	5.18b	53.67a
100	74.81	11.22	166.44	7.21b	5.29ab	59.24a
120	78.52	11.78	146.31	7.71ab	5.37ab	60.62a
140	74.07	11.11	151.16	8.50a	5.63a	57.82a
LSD 0.05	NS	NS	34.79	1.14	0.59	8.28
V × N	17.65	2.70	NS	1.98	1.02	NS

Plant leaf area (cm²)

The perusal of (table 2) revealed that Plant Leaf area was significantly influenced by varieties (V) nitrogen (N) and interaction between V × N was significantly different from each other. Higher plant Leaf area (8.36 cm²) was observed in Ronaldo followed by Senna-Red (6.63 cm²) while lowest (6.16 cm²) were recorded in HZD 00-112. It might be due to genetic potential of the varieties to utilize available nitrogen and synthesis food for growth and increasing plant leaf spread area.

Maximum plant leaf (8.50 cm²) area was attained when nitrogen at 140 kg ha⁻¹ was applied. Followed by 120 kg ha⁻¹N (7.71 cm²) while least leaf area (5.85 cm²) was measured in control. This might be due to high nitrogen availability to the plants for the growth and development and lowest was observed in control due to nitrogen deficiency. These results are similar with

[18] when nitrogen level was increased it increases leaf area.

Higher leaf area (10.25 cm²) was recorded with in Ronaldo when 120 kg ha⁻¹N was given (N₄) while lowest leaf area (4.71 cm²) was noted in Senna-Red at control (N₀). The results revealed that leaf area increased significantly with increasing nitrogen rates using different concentration. This increase has a positive effect on the photosynthetic rate and leaf area. [2] concluded that leaf area of potato was increased by the application of nitrogen at 0.1656 g plant⁻¹.

Maximum leaf length (cm)

An examination of the arrangement (table 2) led to the results that maximum leaf length was significantly affected by varieties (V) nitrogen (N) and interaction between V × N was significantly different from each other. Maximum leaf length (5.36 cm) was observed in Senna-Red. This was followed by HZD 00-112 (5.12 cm) leaf length. The minimum leaf length (4.99

cm) was observed in Ronaldo. It might be due to genetic potential to utilize available nitrogen and synthesis food for growth and increasing leaf length.

Higher leaf length (5.63 cm) was noted with 140 kg ha⁻¹N followed by 120 kg ha⁻¹N (5.37 cm) while lowest leaf length (4.29 cm) was found in control. This might be due to high nitrogen availability to the plants for the growth and development of leaf length and lowest was observed in control due to nitrogen deficiency. These results were justified by [18] that nitrogen level increased the leaf length was increased gradually.

Maximum leaf length (6.24 cm) was found in Senna-Red with 140 kg ha⁻¹ N (N₅) while

least leaf length (3.53 cm) was recorded in Ronaldo at control (N₀). This may be due to the reason that leaves are rich source and main place for chlorophyll which prepared plant food material and nitrogen is essential element of chlorophyll, it helps in protein synthesis during photosynthesis process and nitrogen helps in plant growth and development. These results are in conformity with [19] reported that increased rates of nitrogen increased leaf length of the plant. [20] also stated that application of nitrogen causes increases in length of green leaves, plant height and finally number of tubers.

Table 3. Shows mean values for plant height, no of tuber, tuber diameter, tuber weight, TSS and yield as affected by different doses of nitrogen and genotypes of potato

Varieties	Plant height	No. of tuber	Tuber Diameter (cm)	Tuber Weight	Total soluble solids	Yield
Ronaldo	52.56a	8.03a	4.56a	375.07a	3.99a	22.80a
Senna-Red	47.39b	7.01b	4.46a	366.77a	3.92a	17.50b
HZD 00-112	47.59b	6.73b	4.19b	336.13b	4.09a	11.75c
LSD 0.05	3.96	0.88	0.13	23.46	NS	1.85
Nitrogen levels (kg ha⁻¹)						
0	43.11c	6.74c	4.66a	338.72b	3.19c	16.47b
80	50.93ab	7.51ab	4.49ab	359.56b	4.12ab	17.65ab
100	53.20a	6.94bc	4.45ab	356.11b	3.92bc	16.95b
120	49.13b	8.18a	4.27ab	403.22a	4.74a	19.13a
140	49.51ab	6.91bc	4.17b	339.00b	4.03ab	16.55b
LSD 0.05	3.66	0.78	0.59	40.86	0.77	1.48
V × N	NS	1.35	NS	NS	1.33	2.57

Number of branches plant⁻¹

Table 2 shows that the mean of varieties for number of branches plant⁻¹ were 59.45, 52.93, and 47.97 for Ronaldo, Senna-Red, and HZD 00-112, respectively. Mean for nitrogen levels are 60.62, 59.24, and 35.91, for 120 kg ha⁻¹, 100 kg ha⁻¹, and control (N₀) respectively. Number of branches plant⁻¹ was significantly affected by varieties (V) nitrogen (N). The differences were non-significant between variety and nitrogen. Ronaldo variety showed 69.13 highest numbers of branches plant⁻¹ as compared to other genotypes when nitrogen

was given at 120 kg ha⁻¹. The minimum number of branches 31.20 plant⁻¹ was found in HZD 00-112 at control, respectively having significant difference with each other. It is obvious from the results that variety Ronaldo observed standard in number of branches plant⁻¹ and showed superiority on other cultivars. Number of braches depends upon the efficiency of the plant to develop vegetative initial or primordias. Nitrogen significantly increased plant height, number of branches plant⁻¹ in potato. Nitrogen is an important constituent of amino acid protein and

protoplast directly influences plant growth and development through better utilization of photosynthates. The results are similar with [21]. They reported that the differences might be due to genetic differences between variety and nitrogen.

Plant height (cm)

The results regarding plant height of varieties were significantly influence by the application of nitrogen depicted in table 3 while interaction between $V \times N$ was non-significant. Higher plant height (52.56 cm) was observed in Ronaldo followed by HZD 00-112 (47.59 cm) while minimum (47.39 cm) was measured in Senna-Red.

The cultivars mean differed significantly from each other for plant height. The variety HZD 00-112 took highest 54.67cm place in this parameter when nitrogen was applied at 100 kg ha^{-1} (N_3). The least plant height was found in Senna-Red 41.47cm when nitrogen was given at 0 kg ha^{-1} (N_0). This may be because nitrogen promotes vegetative growth. Better availability of nitrogen and enhancing the effect of nitrogen on vegetative growth by increasing cell division and cell elongation. New leaves sometimes ball up rather than expand that is why the plant height increases up to a certain limit of nitrogen dose. The results are in conformity with [22] reported that better availability of nitrogen and the enhancing effect of nitrogen on vegetative growth by increasing cell division and cell elongation. Urea application played an important role in this regard. Since the recovery of nitrogen from splitted dose remain higher than the whole dose of nitrogen applied at planting. Similar result was observed by [23, 24]. They stated that different time of application of nitrogen tended to increase the plant height.

Number of tubers plant⁻¹

Maximum number of tuber plant⁻¹ was significantly affected by varieties (V) nitrogen (N) and interaction between $V \times N$ (Table 3) was significant. Higher number of tuber plant⁻¹ (8.03) was observed in Ronaldo followed by Senna-Red (7.01) while least

(6.73) was recorded in HZD 00-112. The mean of higher number of tubers plant⁻¹ were significantly different among various levels (8.18) was noted with $120 \text{ kg ha}^{-1} \text{N}$ followed by $80 \text{ kg ha}^{-1} \text{N}$ (7.51) while minimum (6.74) was found in control.

Higher number of tubers plant⁻¹ (8.53) was produced with in Ronaldo with $140 \text{ kg ha}^{-1} \text{N}$ (N_5). The variety HZD 00-112 remained second with value 6.07 when nitrogen was given at 0 kg ha^{-1} (N_0) followed by variety Ronaldo. This is the minimum production of tuber plant⁻¹ of variety HZD 00-112. It is evaluated from the results maximum number of tubers was observed in standard variety Ronaldo which showed superiority on other cultivars. Numbers of tubers plant⁻¹ depend mainly on number of stems, total number of stolons and stolons which tuberize. Number of tubers plant⁻¹ increased through nitrogen application. It might be due to the fact that gradual earthing up of soil around the plant base perhaps provided favourable condition for development of more number of stolons and tubers. These results are in conformity with the finding of [25] and Krishnappa who investigated that increased in number of tubers might be due to increased photosynthetic activity and translocation of photosynthates to the root, which might help in the initiation of more stolons in potato. The variety which produces more number of tubers is considered to be the best regarding marketability.

Diameter of tuber (cm)

It is clear from the table 3 that diameter of tuber was significantly affected by varieties (V) nitrogen (N) while interaction between $V \times N$ was significant. Maximum diameter of tuber (4.56 cm) was found in variety Ronaldo followed by Senna-Red (4.46 cm) while minimum diameter of tuber (4.19 cm) was noted in HZD 00-112. It might be due to genetic potential of the varieties to utilize available nitrogen and synthesis food for growth and increasing diameter of tuber. Data also demonstrated that means of nitrogen levels of higher diameter of tuber (4.66 cm) was noted in control followed by

80 kg ha⁻¹N (4.49 cm) while lowest (4.17 cm) was observed with 140 kg ha⁻¹N.

Data indicated that application of nitrogen at the rate of 0 kg ha⁻¹ (N₀) significantly promoted higher tuber growth 4.74cm of variety Senna-Red. Minimum diameter of tuber was found in variety HZD 00-112 (4.09cm) when nitrogen was applied at the rate of 80 kg ha⁻¹. It might be due to the reason that application of nitrogen fertilizers significantly promoted vegetative growth representing the highest values of plant height leaves number, tuber size, and diameter of tubers. These results are in line with [26, 27] revealed that tuber diameter was increased with increasing nitrogen fertilizer up to suitable level.

Average weight of tuber plant⁻¹ (g)

Statistical analysis of data regarding weight of tubers plant⁻¹ is presented in table 3. It shows that varieties (V) nitrogen (N) significantly different among each other while interaction between V × N was non-significant. Mean of varieties showed that higher weight of tuber plant⁻¹(375.07 g) was observed in Ronaldo followed by Senna-Red (366.77 g) while least weight of tubers (336.13 g) was found in HZD 00-112.

Table showed mean of nitrogen that maximum weight of tubers plant⁻¹(403.22 g) was found with 120 kg ha⁻¹N followed by (359.56 g) with 80 kg ha⁻¹ while minimum weight of tubers (338.72 g) was recorded in control (N₀). This might be due to high nitrogen availability to the plants for the growth and development and minimum was noted in control due to nitrogen deficiency. The data pertaining weight of tubers plant⁻¹ was significantly different among each other. Variety Senna-Red 439.67g had maximum weight of tubers as compared to other cultivars when nitrogen was given at 120 kg ha⁻¹ (N₄). While least weight of tubers was found in variety HZD 00-112 (300.33g) when nitrogen was applied at 140 kg ha⁻¹ (N₅). It is predicted from the results that variety Senna-Red produce maximum tuber weight as compared to other genotypes. [28, 3]

reported that it might be due to increase in weight of tuber nitrogen being the constituent of chlorophyll, promoted cell division and cell elongation, functional life of plant and production of carbohydrate. [29] and Walker (1989) also stated that different time of application of nitrogen might be attributed to higher weight of large sized tubers.

Total soluble solids

Maximum total soluble solids were not significantly influenced by varieties (V) while the effect of nitrogen (N) and interaction between V × N was significant table 3. Mean of nitrogen levels showed that higher total soluble solids 4.74 were observed with 120 kg ha⁻¹N followed by 80 kg ha⁻¹N 4.12 while lowest 3.19 was observed in control (N₀).

Data depicted that maximum total soluble solids 5.06 were noted with in variety HZD 00-112 with 120 kg ha⁻¹ N while lowest total soluble solids 2.41 was recorded in Ronaldo at control when nitrogen was given at 0 kg ha⁻¹ (N₀). It might be due interaction of varieties and nitrogen significantly improved tuber quality. [30] Researcher reported that increasing levels of nitrogen resulted in further increase of tuber quality.

Yield of tuber plot⁻¹ ton's ha⁻¹

The main objective of vegetable research is increasing yield. Yield of tuber was significantly affected by varieties (V) nitrogen (N) and interaction between V × N was significant (Table 3). Higher yield of tuber 22.80-ton ha⁻¹ and 17.50-ton ha⁻¹ was observed in Ronaldo and Senna-Red (17.50-ton ha⁻¹) while lowest 11.75-ton ha⁻¹ was observed in HZD 00-112. Mean of nitrogen levels showed that maximum yield 19.13-ton ha⁻¹ was recorded with 120 kg ha⁻¹N remain second 80 kg ha⁻¹N 17.65-ton ha⁻¹ while minimum yield (16.47-ton ha⁻¹) was noted in control.

Interaction between varieties and nitrogen showed that higher yield of tuber 19.13-ton ha⁻¹ produced by variety Ronaldo when nitrogen was given at 120 kg ha⁻¹N (N₄) this was the highest yield produced by variety

Ronaldo as compared to other genotypes which was significantly different. The variety HZD 00-112 remained second produced lowest yield 9.38-ton ha⁻¹ when nitrogen was applied at 140 kg ha⁻¹N (N₅). According to the results it is clear that Ronaldo variety produced maximum yield 27.85-ton ha⁻¹ and achieved superiority on other cultivars. Yield is a complex quantitative character, which influence by many factors comprising plant, number of branches, number of leaves, leaf area etc. Yield is a main trait the farmers is concerned with high quality and maximum production. These results are consistent with previous reports [31] and Nelson, (1992) and [32] total tuber yield was increased with increasing N rates. [26, 27] concluded that increasing level of nitrogen fertilizer produce maximum tuber yield.

Conclusion

From the results, it is concluded that variety Ronaldo perform better, compared to other varieties and application of 120 kg ha⁻¹ nitrogen give maximum production and production components in agro-climatic condition of Rawalakot, Kashmir-Pakistan.

Authors' contributions

Conceived and designed the experiments: A Yaqub, Performed the experiments: B Amin & A Khan, Analyzed the data: M Ali & A Khan, Contributed reagents /materials/ analysis tools: A Yaqub, M Ullah & M Yayeb, Wrote the paper: M Ali & M Ayaz.

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