The Bioscan 11(4): 2581-2584, 2016 (Supplement on Agronomy)
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.com

EFFECT OF PHOTOPERIODS, GENOTYPES AND THEIR INTERACTIONS ON QUALITY TRAITS OF POTATO (*SOLANUM TUBEROSUM* L.)

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KEYWORDS
Photoperiod
Potato
Genotype
Quality

Received on :
16.06.2016

Accepted on :
22.10.2016

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ABSTRACT
Present study was conducted at G.B. Pant University of Agriculture and Technology Pantnagar during *rabi* season to determine the relationship between photoperiod and potato genotypes with respect to quality. Study showed significant differences among genotypes, photoperiods and their interactions for total soluble solids (TSS), protein and ascorbic acid content. In case of dry matter and specific gravity, effects of genotypes and photoperiods were found to be significant but their interactions between them showed non-significance. Differences in the entire traits between two photoperiods P_1 and P_2 were found significant. Mean values for different traits revealed that plant under extended photoperiod have shown maximum TSS (5.27%), dry matter (18.77%), specific gravity (1.35 g/cm^3), protein (1.46%) and ascorbic acid (4.97mg/100g) content. Among all the interactions between photoperiods and genotypes both Kufri Chipsona-2 and Kufri Chipsona-3 under extended (22.50 and 22.00%, respectively) and normal (20.63 and 20.56%, respectively) photoperiod gave better results in comparison to other interactions. For protein content, among all the interactions genotypes C-15, EM-1, AICRP-08-2 under extended photoperiod and Kufri Bahar under normal photoperiod were better than other interactions. The mean values of above interactions were 1.80, 1.76, 1.69 and 1.68%, respectively. Most of the quality traits were better under extended photoperiod.

INTRODUCTION

The potato (*Solanum tuberosum* L.) is a vegetable crop of major economic importance worldwide. It is the fourth most cultivated food crop after wheat, rice and maize (Jones *et al.,* 1994). Potato is used as vegetable, stock feed and in industries for manufacturing starch, alcoholic beverages and other processed products. It is an important temperate crop which has been adopted well for cultivation under sub-tropical conditions. It is a starchy, tuberous crop from the perennial genus *Solanum* of the Solanaceae family. Potato is an integral part of human diet. It produces more protein (524 kg/ha) as compared to wheat (254 kg/ha) (Sazid and Aftab, 2009). Potato tubers contain about 80 per cent water and the rest is dry matter. Starch is the major component of the dry matter accounting approximately 70 per cent of the total solids. Potato is a cheap source of energy and good supplier in relation to requirement of dietary nitrogen of high quality and was pre-eminent as a source of vitamin C, vitamin B, high dry matter, mineral and carbohydrates per unit area (Gopalan *et al.*, 1972).The average raw material composition of a potato tuber is as dry matter (20%), starch (13-16%), total sugars (0-2%), protein (2%), fibre (0.5%), lipids (0.1%), vitamin C (31 mg/ 100 g fresh weight), minerals (trace), ash (1-1.5%), and amylase (22-25%). Two major environmental factors that control development of potato are temperature and photoperiod. These factors are represented in crop development simulation models by temperature and photoperiod response functions. Potato is a short-day plant for tuber initiation and long-day or neutral plants for flowering, *i.e.* short-days accelerate tuber initiation and delay flowering (Van Dam *et al.*, 1996). Photoperiod response in potato is dependent on genotype and on developmental phases (Kooman *et al.*, 1996).

Dories *et al.* (1995) observed that Sweet pepper could also benefit from an extended light period. Under continuous photoperiod, the photosynthetic rate was higher and more photo assimilates were translocated to the fruit. Diurnal translocation rates were 2 to 3 times higher under 18h and 24h photoperiod than 12h lighting and linear relationship between translocation rate and photosynthetic rate was observed. Stutte *et al.* (1996) found that in potato plants grown under 24hp hotoperiod, photosynthesis was 33% lower than in plants grown under 12h photoperiod. Therefore, the present study was conducted to assess the effects of photoperiod on quality traits of different potato genotypes.

MATERIALS AND METHODS

The experiment was conducted at Vegetable Research Centre of Govind Ballabh Pant University of Agriculture and Technology Pantnagar, District Udham Singh Nagar,

Uttarakhand during *rabi* season of 2012-13. Geographically, Pantnagar situated at 29.5º N latitude, 79.3º E longitude and having an altitude of 243.8 meters above the mean sea level in sub-mountainous region of Shivalik hills, known as *tarai*. The climate of Pantnagar is sub humid, subtropical with hot dry summers and cool winters. The summer temperature rises up to 46ºC, while the winter temperature falls to 2ºC. The mean annual rainfall is 2382 mm and relative humidity fluctuates around 98% during rainy season and remains above 85% in February after which it decreases up to 5% in May. The experiment material consisted of 17 genotypes (EM-1, Pant Selection 09-53, C-19, TPSK-05-06-110, Kufri Surya, MM-12, MM-7, TPSK-05-06-002, Laddy Roseta, C-15, Kufri Bahar, B-420, Pant Selection 09-15, C-4, AICRP- 08-2, C-14, C-17), with 3 checks (Kufri Pukhraj, Kufri Chipsona-2, Kufri Chipsona-3) and two photoperiods *viz*. normal photoperiod (P_1) of 10 hours and extended photoperiod (P_2) providing 5h extra light through fluorescent bulb up to 16 hours. The extended photoperiod was provided to the plants in the growing season for 3 months (November-January) upto dehaulming of crop. The experiment was laid out in two factorial randomized block design (Cochran and Cox, 1957). Observations regarding Total Soluble Solids (TSS) were determined with the help of hand refractometer (Erma, Japan) in °Brix, tuber dry matter content was determined using 100 g of tuber tissue chopped and dried at 105 °C for 48 hr to ensure complete drying (Birhman *et al.*, 1988), specific gravity (g/cm^3) calculated as earlier described by Birhman *et al*. (1988), ascorbic acid content in mg/100g fresh weight of the tuber was determined at final harvesting stage by the method of Ranganna (1986), protein content was determined in per cent through Micro-Kjeldhal method (Ranganna, 1986).

RESULTS AND DISCUSSION

TSS (%)

Among genotypes the TSS ranged from 3.71 to 6.96 °Brix and it were found maximum in Kufri Pukhraj (6.96 º Brix), while the lowest TSS were recorded in C-15 (3.71º Brix). None of the genotypes were found significantly higher than the highest check Kufri Pukhraj (6.96 ºBrix). However, genotypes, C-15 (3.71 ºBrix), C-14 (4.36º Brix) and MM-7 (4.61 ºBrix) were found significantly lower than the lowest check Kufri Chipsona-2 (4.71 ºBrix). Out of 20 genotypes, only one genotype was found superior under normal photoperiod over best check Kufri Pukhraj (6.33 ºBrix) *viz*. AICRP-08-2 (6.36 ºBrix) produced significantly higher TSS. However under extended photoperiod no genotype performed better than the best check Kufri Pukhraj (7.60 °Brix). Among all the interactions, Kufri Pukhraj (in P_2) followed by AICRP-08-2 (in P_1), Kufri Pukhraj (in P_1) and Kufri Bahar (in P_2) gave better results in comparison to other interactions. The mean values of above interactions were 7.60, 6.36, 6.33 and 6.16 %, respectively. Wang *et al*. (2012) observed that due to down regulation of photosynthesis and electron transport components in low light grown plants, there was a significant increase in malondialdehyde (MDA) concentration, superoxide dismutase (SOD), peroxidase (POD) activities and decrease in TSS.

Dry matter content (%)

Dry matter content ranged from 15.80% to 21.56% and it was maximum in Kufri Chipsona-2 (21.56%), while the lowest dry matter was observed in TPSK-05-06-110 (15.80%). Out of twenty genotypes, no genotype was found superior under normal photoperiod over best check Kufri Chipsona-2 (20.63%). Whereas under extended photoperiod none of the genotypes performed better than the best check Kufri Chipsona-2 (22.50%). Among all the interactions between photoperiods and genotypes both Kufri Chipsona-2 and Kufri Chipsona-3 under extended (22.50 and 22.00%, respectively) and normal (20.63 and 20.56%, respectively) photoperiod gave better results in comparison to other interactions. This is possibly due to increased dry matter content up to the last stage of harvest in both the photoperiods, but in high light intensity it was observed higher by Marwaha and Sandhu (2002).

Specific gravity (g/cm^3)

Among the genotypes the specific gravity ranged from 1.08 g/cm^3 to 1.68 g/cm^3 and it was maximum in Kufri Pukhraj (1.68 g/cm^3), while the lowest specific gravity was found in Kufri Bahar (1.08 g/cm^3). No genotype was found significantly higher than the highest check Kufri Pukhraj (1.68 g/cm^3) whereas two genotypes *viz*. Kufri Bahar (1.08 g/cm^3) and Kufri Surya (1.09 g/cm^3) were found significantly lower than the lowest check Kufri Chipsona-2 (1.13 g/cm^3). Out of total twenty genotypes, only one genotype, AICRP-08-2 (1.59 g/cm^3) was found superior under normal photoperiod over best check Kufri Pukhraj (1.55 g/cm^3) that showed significantly higher specific gravity. Whereas under extended photoperiod none of the genotypes performed better than the best check Kufri Pukhraj (1.81 g/cm^3). Among all the interactions, Kufri Pukhraj (in P_2) followed by AICRP-08-2 (in P_2), AICRP-08-2 (in P_1) and C-4 (in P_2) gave better results in comparison to other interactions. The mean values of above interactions were 1.81, 1.71, 1.59, and 1.58 g/cm^3, respectively. These results are supported by earlier work of Marrwaha and Sandha (2002).

Protein content (%)

Among the genotypes the protein content ranged from 1.21 to 1.72% and it was maximum in C-15 (1.72%), while the lowest protein content was recorded in B-420 (1.21%). Genotypes EM-1 (1.39%), C-19 (1.44%), TPSK-05-06-110 (1.53%), Kufri Surya (1.59%), MM-12 (1.44%), Lady Roseta (1.57%), C-15 (1.72%), Kufri Bahar (1.44%), C-4 (1.45%) and C-14 (1.49%) were found significantly higher than the highest check Kufri Pukhraj (1.37%) and only one genotype B-420 (1.21%) was found significantly lower than the lowest check Kufri Chipsona-2 (1.26%). Out of 20 genotypes, four genotypes were found superior under normal photoperiod over the best check Kufri Pukhraj (1.53%) *viz*. Kufri Surya (1.60%), Kufri Bahar (1.68), C-14 (1.55%) and C-15 (1.64%) produced significantly higher protein. However under extended photoperiod genotypes, C-19 (1.36%), C-4 (1.40%), TPSK-05-06-002 (1.47%), MM-12 (1.51%), Pant Sel-09-53 (1.58%), Kufri Surya (1.58%), TPSK-05-06-110 (1.67%) Lady Roseta (1.68%), AICRP-08-2 (1.69%), EM-1 (1.76%) and C-15 (1.80%) performed better than the best check Kufri Chipsona-3 (1.35%). Among all the interactions under extended photoperiod, C-15, EM-1, AICRP-08-2 and Kufri Bahar under normal photoperiod gave better results in comparison to other

Table 2: Effectof photoperiod, genotypes and their interactions on protein and vitamin C of potato

Genotypes	Protein (%)			Vitamin C (mg/100 g)		
	P^1	P^2	Mean	P^1	P^2	Mean
EM-1	1.02	1.76	1.39	5.08	5.51	5.29
AICRP-08-2	1.64	1.69	1.66	4.69	4.98	4.83
Pant Sel-09-53	1.16	1.58	1.37	4.59	5.52	5.06
C-19	1.52	1.36	1.44	4.67	4.95	4.81
TPSK-05-06-110	1.40	1.67	1.53	5.10	5.50	5.30
Kufri Surya	1.60	1.58	1.59	3.84	4.42	4.13
MM-12	1.37	1.51	1.44	6.03	5.38	5.71
MM-7	1.41	1.28	1.34	3.80	4.11	3.95
TPSK-05-06-002	1.27	1.47	1.37	5.14	5.04	5.09
Lady Roseta	1.45	1.68	1.57	3.62	3.93	3.77
C-15	1.64	1.80	1.72	4.70	5.04	4.87
Kufri Bahar	1.68	1.20	1.44	4.17	5.34	4.76
B-420	1.15	1.27	1.21	5.28	5.56	5.42
Pant Sel-09-15	1.14	1.51	1.33	4.92	5.49	5.20
C-4	1.50	1.40	1.45	4.28	4.84	4.56
K. Chipsona-2	1.23	1.29	1.26	3.11	4.51	3.81
Kufri Pukhraj	1.53	1.21	1.37	4.37	4.33	4.35
K. Chipsona-3	1.21	1.35	1.28	3.80	4.33	4.06
C-14	1.55	1.43	1.49	5.12	5.31	5.21
C-17	1.29	1.23	1.26	4.01	5.28	4.64
Mean	1.39	1.46	1.42	4.51	4.97	4.74
	P	G	P X G	P	G	P X G
S.Em.±	0.014	0.045	0.064	0.049	0.156	0.221
CD at 5%	0.040	0.128	0.181	0.139	0.440	0.622

Table 1: Effectof photoperiod, genotypes and their interections on TSS, dry matter and specific gravity of potato

Genotypes	TSS (%)			Dry matter (%)			Specific gravity (g/cm^3)		
	P^1	P^2	Mean	P^1	P^2	Mean	P^1	P^2	Mean
EM-1	3.72	4.30	4.01	17.73	18.70	18.21	1.15	1.28	1.21
AICRP-08-2	6.36	5.60	5.98	14.50	16.23	15.36	1.59	1.71	1.65
Pant Sel-09-53	5.23	5.60	5.41	17.50	18.06	17.78	1.43	1.50	1.47
C-19	4.73	5.0	4.86	15.66	17.00	16.33	1.24	1.28	1.26
TPSK-05-06-110	5.66	5.60	5.63	15.20	16.40	15.80	1.10	1.18	1.14
Kufri Surya	4.33	4.43	4.38	16.33	17.00	16.66	1.10	1.07	1.09
MM-12	4.63	6.10	5.36	15.7	16.26	15.98	1.24	1.15	1.19
MM-7	4.53	4.70	4.61	15.10	17.00	16.05	1.21	1.40	1.31
TPSK-05-06-002	4.20	4.26	4.23	18.36	21.36	19.86	1.36	1.40	1.38
Lady Roseta	5.30	5.50	5.40	15.76	16.33	16.05	1.51	1.59	1.55
C-15	3.73	3.70	3.71	19.83	21.63	20.73	1.13	1.22	1.17
Kufri Bahar	5.30	6.16	5.73	16.56	19.34	17.95	1.05	1.11	1.08
B-420	5.05	5.40	5.22	18.63	21.30	19.96	1.34	1.35	1.35
Pant Sel-09-15	5.20	5.63	5.41	17.00	16.30	16.65	1.15	1.19	1.17
C-4	4.06	5.53	4.80	18.36	19.16	18.76	1.49	1.58	1.53
K. Chipsona-2	4.50	4.93	4.71	20.63	22.50	21.56	1.16	1.09	1.13
Kufri Pukhraj	6.33	7.60	6.96	17.43	19.33	18.38	1.55	1.81	1.68
K. Chipsona-3	5.46	5.0	4.78	20.56	22.00	21.28	1.40	1.50	1.45
C-14	4.23	4.50	4.36	19.36	21.16	20.50	1.44	1.53	1.48
C-17	4.76	5.96	5.36	16.33	18.00	17.16	1.17	1.16	1.15
Mean	4.82	5.27	5.05	17.33	18.77	18.05	1.29	1.35	1.32
	P	G	P X G	P	G	P X G	P	G	P X G
S.Em.±	0.051	0.164	0.232	0.198	0.627	0.887	0.017	0.056	0.079
CD at 5%	0.146	0.462	0.653	0.558	1.766	NS	0.049	0.158	NS

interactions. The mean values of above interactions were 1.80, 1.76, 1.69, and 1.68%, respectively. The above results are in accordance with the findings of Wang *et al*. (2012).

Ascorbic acid (mg/100g)

Among the genotypes ascorbic acid ranged from 3.77 to 5.71 mg/100g and it was maximum in MM-12 (5.71 mg/100g), while, the lowest ascorbic acid content was recorded in Lady Roseta (3.77 mg/100g). Genotypes EM-1 (5.29 mg/100g), AICRP- 08-2 (4.83 mg/100g), Pant Sel. 09-53 (5.06 mg/100g), C-19 (4.81 mg/100g), TPSK-05-06-110 (5.30 mg/100g), MM-12 (5.71 mg/100g), TPSK-05-06-002 (5.09 mg/100g), C-15 (4.87 mg/100g), Kufri Bahar (4.76 mg/100g), B-420 (5.42 mg/100g), Pant Sel. 09-15 (5.20 mg/100g), C-4 (4.56 mg/100g), C-14 (5.21 mg/100g) and C-17 (4.64 mg/100g) were found

significantly higher than the highest check Kufri Pukhraj (4.35 mg/100g) whereas only one genotype Lady Roseta (3.77 mg/100g) was found significantly lower than the lowest check Kufri Chipsona-2 (3.81 mg/100g). Out of 20 genotypes, EM-1 (5.08 mg/100g), Pant Sel. 09-53 (4.59 mg/100g), C-19 (4.67 mg/100g), TPSK-05-06-110 (5.10 mg/100g), MM-12 (6.03 mg/100g), TPSK-05-06-002 (5.14 mg/100g), C-15 (4.70 mg/100g), B-420 (5.28 mg/100g), Pant Sel. 09-15 (4.92 mg/100g), AICRP-08-2 (4.69 mg/100g) and C-14 (5.12 mg/100g) were found superior under normal photoperiod over the best check Kufri Pukhraj (4.37 mg/100g) that produced significantly higher ascorbic acid content. Whereas under extended photoperiod genotypes EM-1 (5.51 mg/100g), Pant Sel. 09-53 (5.52 mg/100g), C-19 (4.95 mg/100g), TPSK-05-06-110 (5.50 mg/100g), MM-12 (5.38 mg/100g), TPSK-05-06-002 (5.04 mg/100g), C-15 (5.04 mg/100g), Kufri Bahar (5.34 mg/100g), B-420 (5.56 mg/100g), Pant Sel.-09-15 (5.49 mg/100g), C-4 (4.84 mg/100g), AICRP- 08-2 (4.98 mg/100g), C-14 (5.31 mg/100g) and C-17 (5.28 mg/100g) performed better than the best check Kufri Chipsona-2 (4.51 mg/100g). Among all the interactions, genotype MM-12 in normal photoperiod and genotypes, B-420, Pant Sel.-09-53 and EM-1under extended photoperiod gave better results in comparison to other interactions. The mean values of above interactions were 6.00, 5.56, 5.52, and 5.51 mg/100g, respectively. Increase in photosynthesis due to high light intensity which resulted in increased ascorbic acid.

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