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EVALUATION OF EXOTIC POTATO GERMPLASM FOR HIGH YIELD AND DISEASE RESISTANCE UNDER LOCAL CONDITIONS

A. Shehroz[1], M. M. Hussain[2], I. Ramzan[3] and M. A. Ali[1,4*]

[1]Department of Plant Pathology, University of Agriculture, Faisalabad, Pakistan; [2]Potato Research Institute, Sahiwal, Pakistan; [3]Department of Agronomy, University of Agriculture, Faisalabad, Pakistan; [4]Centre of Agricultural Biochemistry and Biotechnology (CABB), University of Agriculture, Faisalabad, Pakistan.
Corresponding Author's E-mail: amjad.ali2001@gmail.com, amjad.ali@uaf.edu.pk

ABSTRACT

Potato is an important food crop of Pakistan due to its high usage in food processing industry. This study was carried out at Potato Research Institute, Sahiwal. The plantation was done by maintaining plant to plant and row to row distances as 20 and 75 cm respectively. Potato varieties were screened against three diseases such as common scab, rhizoctonia, cracking and various tuber attributes such as germination, tuber size and yield were also evaluated. It was revealed from the data that potato variety 171 gave the highest yield of 35.5 t/ha followed by Masai with 31.0 t/ha. The maximum emergence was shown by the Variety Red Sun 89.7%. However, the lowest emergence was shown by the variety Camel 71.7%. Regarding tuber grades, it was noted that the maximum tuber size were produced by the Compass (3.7%), whereas 11 varieties did not produce large size tubers at all. The variety Red Sun produced lowest percentage of small size tubers 12.7%, whereas maximum small size tubers (93.0%) were produced by the variety Jitka. Regarding diseases data, it was noticed that the maximum scab incidence 4% was recorded on the variety Masai, maximum rhizoctonia attack 60% was recorded on the variety Camel and maximum tuber cracking (0.7%) was noted on the variety Vendulla. The results conclude that several exotic potato varieties identified during this study could be adapted for local cultivation to enhance potato production in the country.

Keywords: Cracking, exotic germplasm, disease resistance, potato,tuber yield.

INTRODUCTION

Potato (*Solanum tuberosum* L) is the third most consumable food crop of the world after wheat and rice (Haverkort *et al.,* 2009). It is established as staple food in some European countries (Leeman *et al.,* 2005). Being rich in starch (one of the main three food ingredients) and having the highest productivity per unit area, potato has great potential to address the challenges of the food security in the world. Potato is an economical food since it is a source of low cost energy to the human diet (Leeman *et al.,* 2005). It is also a good source of vitamins and minerals (Low *et al.* 2007). It is free from cholesterol, contains some antioxidants to help in providing protection against heart diseases and cancer (Al-Saikhan *et al.,* 1995). It also helps to control hypertension and high blood pressure due to its kukoamine content (Akande *et al.,* 2000). The per unit area production of potato in Pakistan is less than other countries due to many reasons i.e., unavailability of good seed, water scarcity, biotic and abiotic factors (Khan *et al.,* 1985). Mostly potato seed is imported from different countries due to unavailability of local seed to the farmers (Struik and Wiersema, 1999). Potato is a food crop influenced by many diseases as compare to other food crops, and infected tubers serve as a source for spread of diseases. The potato seed imported from different countries brings diseases with them (Secor and Rivera-Varas, 2004). Lack of adaptability trial of these exotic potato varieties results in low yield and emergence of new diseases in local areas. Potato late blight [*Phytophthora infestans* (Mont.) de Bary] has re-emerged as a major threat for achieving production potential of potato worldwide in recent few years (Fry and Goodwin, 1995). Some varieties show resistance against late blight of potato need continuous screening before cultivation in growing season (Kirk *et al.,* 2001). Bacterial wilt caused by a bacterium (*Ralstonia solanacearum*) results in a soil borne vascular disease which contributes towards low yield and reduces the market value of potato. This bacterium causes diseases in 450 plant species including tomatoes, potatoes, eggplant and banana (Andviron, 1995). Black scurf disease of potato caused by fungus (*Rhizoctonia solani*) is found in almost all potato growing areas of Pakistan and the fungus has the ability to survive even in harsh environmental conditions (Parvez *et al.*, 2003; Allen *et al.*, 2005). Common scab of potato caused by bacterium *Streptomyces scabies* is an important disease of potato found throughout potato cultivated areas of the world (Rauf, 2002). From disease management point of view, it is a need of time to implement control measures for movement of potato from one country to another especially in case of seed potato, so introduction of new diseases could be minimized.

Different types of controls measures could be

used to inhibit these diseases below threshold level. For instance, most prevalent method is chemical control which contributes towards human health hazards (Rauf, 2002). The selection of resistant potato cultivars is an important step in management of diseases. The other strategy to control these diseases could be screening of disease resistant varieties among exotic potato seed. Exotic germplasm of potato may contain useful traits which could be used in future for improving disease resistance and yield potential in cultivated potatoes. The main objective of this study was to screen out exotic potato varieties which show significant resistance against diseases and have high yield potential.

MATERIALS AND METHODS

This study was done at Potato Research Institute Sahiwal (PRI) during 2014-2015 cropping season. A total of 20 exotic varieties 171, Masai, Red sun, Rock, Compass, Red valentine, Amarin, Dirasso, Triplo, Toscana. Ludmilla, Lady Sara, Vendulla, Bohemia, Jannet, Camel, Terka, Red Anna, Jitka and KWS-06-125 along with two checks Simply Red and Sante were sown in November, 2014. The trial was conducted according to the randomized complete block design with three replications. Plant to plant and row to row distances were maintained as 20 cm and 75 cm, respectively. The plot size was 6.0 m x 2.25 m (13,5 m^2). Normal agronomic and plant protection measures were carried out in the crop. The harvesting was done on April, 2015. During this study, data regarding tuber size, emergence rate, tuber yield and diseases was recorded.

Screening of potato germplasm for tuber size: Tuber size of potato germplasm was evaluated at the time of harvesting. Potato tuber's size was measured with the help of measuring meter at the time of harvesting; potato tubers were sorted out on their size basis following Pedreschi *et al.* (2006) and Shahnazari *et al.* (2007). Evaluation of tuber size of these exotic potato varieties was done according to the criteria given in Table-1.

Table 1. The evaluation of varieties on the basis of tuber size.

Tuber Grade	Response of potato germplasm
<35 mm	Small
35-55 mm	Normal (seed size)
>55 mm	Large (food processing size)

Screening of potato germplasm for tuber Diseases (Scab, Rhizoctonia and Crack): Tuber diseases i.e.; scab, rhizoctonia and crack of potato germplasm were evaluated at the time of harvesting. The screening was done on the bases of symptoms shown by potato tubers. Potato tubers affected with these diseases were separated out and percentage was calculated by dividing these tubers with total number of tubers. Confirmation of these diseases was done by isolation of and then growing these disease related pathogens on culture media (Davis *et al.,* 1981). After colony formation temporary slides were made and observed under stereomicroscope (Hirose *et al.,* 2001). The evaluation of tuber disease of these varieties was done on the basis of criteria given in Table-2.

Table 2. Response of varieties against different diseases.

Tuber Diseases %	Response of potato germplasm
0-1	Immune
2-3	Resistant
4-6	Moderately Resistant
7-9	Tolerant
10-15	Susceptible
16-20	Moderately Susceptible
21-25	Highly Susceptible

Evaluation of potato germplasm for tuber yield: Assessment of exotic potato varieties for tuber yield was done at the time of harvesting. Potato yield was calculated by using weighing balance. The yield was calculated as tons per hectare (Onder *et al.,* 2005). The evaluation of tuber yield of these varieties was done on the basis of criteria given in the following table.

Table 3. Yield scoring Scale.

Tuber Yield (t/ha)	Response of potato germplasm
1-10	Low yields
11-20	Normal yields
21-40	High yields

RESULTS AND DISCUSSION

Screening of potato germplasm for tuber size: The exotic potato germplasm consisting of 20 varieties showed a range of variability for tuber size (Table-4). The complete data regarding tuber size is given in Table-5. On the basis of grading of tuber size as shown in Table-1, a wide range of variability was noted ranging from small to large tuber size as given in Table-5. Tuber size was recorded on 20 exotic potato varieties at the time of harvesting in April, 2105. It is revealed from the data regarding tuber grades that the maximum large size tubers were produced by the exotic variety Compass (3.7%), whereas 11 varieties did not produce large size tubers at all. The variety Red Sun produced lowest percentage of small size tubers (12.7%) whereas maximum small size tubers (93.0%) were produced by the variety Jitka. Size of tuber (large, small) depends on heritable and environmental factors (Eisler, 2000)

Table 4: Mean squares of various traits of exotic Potato varieties

CHARACTERS	MEAN SQUARES
Emergence	152.369
Small size tubers	2390.08**
Medium size tubers	2308.78**
Large size tubers	3.83261**
Scab	2.79149**
Cracking	10.8088
Rhizoctonia	36.9897
Yield	336.720**

Whereas ** means highly significant at P≤0.01

Screening of potato germplasm for tuber Diseases (Scab, Rhizoctonia and Crack): The exotic potato germplasm consisting of 20 varieties resulted in lot of variability for tuber disease. The full data regarding tuber diseases is given in Table-5. Based on the scaling of tuber diseases as given in Table-2, a wide range of different groups of genotypes were found ranging from immune to highly susceptible which are shown in Table-5. Tuber diseases data was recorded on 20 exotic potato varieties at the time of harvesting in April, 2105. Regarding disease infestation, it was noted that the maximum scab incidence (4.0%) was recorded on the variety Masai, maximum rhizoctonia attack (60.0%) was recorded on the variety Camel which was highly susceptible to rhizoctonia and maximum tuber cracking (0.7%) was noted on the variety Vendulla. Common scab of potato is caused by bacterium Streptomyces scabies. Rough texture lesions are produced on the surface of tuber tan to dark brown in colours given in the Figure 1a. Cracking of tubers occur due to surrounding environment in the soil (Park *et al.*, 2002; Tai and Young, 1984). Tubers with cracks reduced the market value of potato as well as sit for infection for other microorganisms (Hooker *et al.* 1981). Disease incidence was determined by the following formula.

Table 5. Screening of potato varieties against emergence, tuber grade, diseases and yield.

Rank	Variety	Emergence (%)	Tuber Grade (%)			Tuber Diseases (%)			Yield (t/ha)
			<35 mm	35-55 mm	>55 Mm	Scab	Rhizoctonia	Crack	
1	171	80.3	15.0	75.7	3.0	0.3	2.0	0.3	**35.5**
2	Masai	87.3	14.0	76.0	1.3	**4.0**	23.0	0.0	31.0
3	Red sun	**89.7**	**12.7**	78.0	2.3	0.0	0.3	0.0	31.0
4	Rock	87.7	22.0	69.0	1.7	0.0	2.7	0.0	31.0
5	Compass	76.0	20.0	72.3	**3.7**	0.7	4.3	0.3	29.0
6	Red valentine	89.0	28.0	67.7	0.7	0.0	1.3	0.0	28.3
7	Amarin	87.7	16.3	77.0	2.3	0.0	44.3	0.0	28.2
8	Dirasso	87.7	15.3	77.3	0.0	0.0	10.3	0.0	28.0
9	Simply Red	89.0	20.3	72.7	1.7	1.7	6.3	0.0	24.2
10	Triplo	80.7	24.7	75.3	0.0	0.0	7.3	0.0	23.7
11	Toscana	85.7	31.3	67.7	0.0	1.0	38.0	0.3	23.2
12	Santé	89.3	27.7	68.7	0.0	1.7	28.3	0.0	21.5
13	Ludmilla	81.7	40.7	58.0	0.3	1.3	58.0	0.3	21.0
14	Lady sara	87.0	18.7	74.7	0.7	0.0	0.0	0.0	18.7
15	Vendulla	74.7	51.7	46.0	0.0	0.0	3.3	**0.7**	16.7
16	Bohemia	87.3	36.3	63.7	0.0	0.0	9.0	0.0	16.3
17	Jannet	81.3	15.7	75.3	1.0	1.3	10.7	0.0	12.7
18	Camel	**71.7**	92.3	26.0	0.0	0.0	**60.0**	0.0	5.5
19	Terka	87.0	90.0	26.0	0.0	0.0	1.7	0.0	4.3
20	Red Anna	77.7	19.7	74.3	0.0	0.7	2.3	0.0	4.0
21	Jitka	80.0	**93.0**	26.0	0.0	0.0	6.3	0.3	2.8
22	KWS-06-125	74.0	89.7	26.0	0.0	0.3	52.3	0.0	1.5

$$\text{Disease incidence\%} = \frac{\text{No. of tubers affected}}{\text{Total no. of tubers observed}} \times 100$$

Screening of potato germplasm for yield: The potato varieties were evaluated on the bases of yield at the time of harvesting (Perombelon and Kelman 1980). Potato yield was calculated by using weighing balance (Bleasdale, 1965; Ojala *et al.*, 1990). It is revealed from the data that exotic variety 171 gave the highest yield of 35.5 t/ha followed by Masai with 31.0 t/ha tuber yield. The check variety SimplyRed gave 24.2 t/ha yield, while the lowest tuber yield (1.5 t/ha) was produced by the exotic variety KWS-06-125.

Regarding the emergence it is notices that the

maximum emergence was shown by the Variety Red Sun (89.7 %). The lowest emergence was shown by the variety Camel (71.7%).

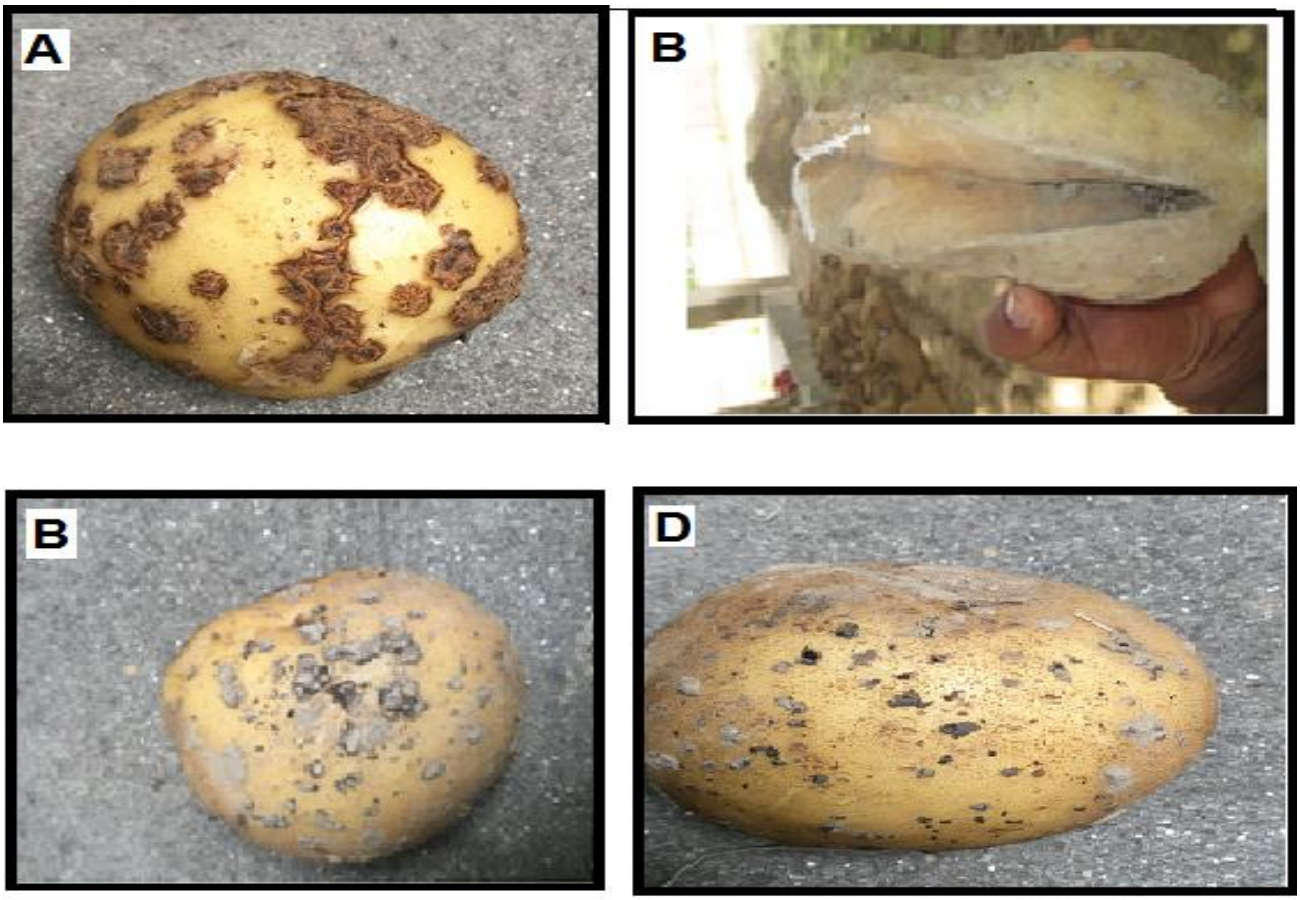

Figure 1: A: Common scab of potato caused by bacterium *Streptomyces scabies*, B: Cracking of tuber due to surrounding environmental conditions in soil, C&D: Black scurf disease of potato caused by fungus *Rhizoctonia solani*

Conclusions: Most of these exotic potato varieties have significant degree of yield potential and disease resistance with high rate of emergence. There is genetic variation in potato germplasm for tuber size (for food processing) and it is revealed from data that some varieties show good response in various traits and could be adapted for local cultivation in future.

REFERENCES

Akande, A., C. D. W. Van Wyk, and J. E. Osagie (2000). Importance of exercise and nutrition in the prevention of illness and the enhancement of health. Education. 120(4): 758.

Allen, C., P. Prior and C. Hayward (2005).Bacterial Wilt Disease and the Ralstonia solanacearum Species Complex. APS Press, St. Paul, MN, USA. 528p

Al-Saikhan, M.S., L. R. Howard , and J. C. Miller (1995). Antioxidant activity and total phenolics in different genotypes of potato (Solanum tuberosum, L.). J. Food Sci. 60(2): 341-343.

Andviron, R. (1995). Comparison of race structure and diversity in populations of Phytophthora infestans, In: Dowley, L.J., E. Bannon, L.R. Cooke, T. Keane and E.O. Sullivan (1966-1993). Phytophthora infestans 150. Boole Press, Dublin. Pp. 71-76.

Bleasdale, J. K. A. (1965). Relationships between set characters and yield in main crop potatoes. J. Agri. Sci. 64(3): 361-366.

Davis, Michael J., William J. French, and Norman W. Schaad (1981).Axenic culture of the bacteria associated with phony disease of peach and plum leaf scald. Curr. Microbiol. 6 (5): 309-314.

Eisler, R. (2000). Handbook of Chemical Risk Assessment: Health Hazards to Humans, Plants, and Animals, 1. CRC Press.

Fry, E.W., and S.B. Goodwin (1995). Recent migrations of *Phytophthora infestans*. In *Phytopthora*

infestans, 150, ed. L.J. Dowley, E. Bannon, R.L. Cooke, T. Keane, and E. Andosullivan, Dublin: Boole Press. Pp. 89–95.

Haverkort, A. J., P. C. Struik, R. G. F. Visser and E. Jacobsen (2009). Applied biotechnology to combatlate blight in potato caused by *Phytophthora infestans*. Potato Res. 52(3):249-264.

Hirose, M., R. Kinzie and M. Hidaka (2001).Timing and process of entry of zooxanthellae into oocytes of hermatypic corals. Coral Reefs 20 (3): 273-280.

Hooker, W. J. (1981). Compendium of potato diseases (8). I. Potato Center. https:// pdf. usaid. gov/pdf_docs/PNABD692.pdf

Khan, B. A., I. Haq, S. Iftikhar, and M. Aslam (1985). Occurrence of late blight of potato in Pakistan. Pakistan J. Bot. 17(1): 163.

Kirk, W. W., K. J. Felcher, D. S. Douches, B. A. Niemira, R. Hammerschmidt (2001). Susceptibility of potato (*Solanum tuberosum* L.) foliage and tubers to the US8 genotype of Phytophthora infestans. Am. J. Potato Res. 78 (4): 319-322.

Leeman, M, E. Ostman and I. Bjorck (2005). Vinegar dressing and cold storage of potato lowers postprandial glycaemic and insulinaemic responses in healthy subjects. Eur. J. Clin.Nutr. 59 (11):1266-1271.

Low, J. W., M. Arimond, N. Osman, B. Cunguara, F. Zano and D. Tschirley, (2007). A food-based approach introducing orange-fleshed sweet potatoes increased vitamin A intake and serum retinol concentrations in young children in rural Mozambique. The J. Nurt. 137(5): 1320-1327.

Ojala, J. C., J. C. Stark and G. E. Kleinkopf (1990). Influence of irrigation and nitrogen management on potato yield and quality. Am. Potato J. 67(1): 29-43.

Onder, S., M. E. Caliskan, D.Onder, S. Caliskan (2005). Different irrigation methods and water stress effects on potato yield and yield components. Agr. Water manage.73 (1): 73-86.

Park, Y., S. Kim, J. Cho, (2002).Conducive environment and ecology of common scab (*Streptomyces scabies*) of potato. J. Korean Soc. Horti. Sci. 43: 607–612.

Parvez, E., S. Hussain, A. Rashid and M.Z. Ahmad (2003). Evaluation of different protectant and eradicant fungicides against early and late blight of potato caused by A. solani (Eliss and Mart) Jones and Grouht and Phytophthora infestans (Mont.) De Barry under field conditions. Pakistan J. Biol. Sci. 6: 1942-44.

Pedreschi, F., J. Leon, D. Mery, P. Moyano (2006). Development of a computer vision system to measure the color of potato chips. Food Res. Int. 39 (10): 1092-1098.

Perombelon, M. C., and A. Kelman (1980). Ecology of the soft rot erwinias. Ann. Rev. Phytopathol. 18(1): 361-387.

Rauf, C.A. (2002). Biology and management of black scurf of potato.Ph.D Thesis, Department of biological sciences Quaid-i-Azam University, Islamabad, Pakistan.

Secor, G. A. and V. Rivera-Varas (2004). Emerging diseases of cultivated potato and their impact on Latin America. Revista Latinoamericana de la Papa (Suplemento). 1: 1-8.

Shahnazari, A., F.Liu, M. N.Andersen, S. Jacobsen and C.R. Jensen (2007). Effects of partial root-zone drying on yield, tuber size and water use efficiency in potato under field conditions. Field Crops Res. 100 (1): 117-124.

Struik, P. C. and S.G. Wiersema (1999). *Seed potato technology*. Wageningen Academic Pub. https://doi.org/10.3920/978-90-8686-759-2

Tai, G. C., and D. A. Young (1984).Early generation selection for important agronomic characteristics in a potato breeding population. Am. Potato J. 61 (7): 419-434.