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EVALUATION OF POTATO HYBRIDS FOR YIELD COMPONENTS IN HUMID SUBTROPICAL CLIMATE DURING AUTUMN SEASON

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ABSTRACT

Owing to the importance of potato crop, fifty potato hybrids developed by potato program NARC were evaluated for quality traits and yield parameters in randomized complete block design with three replications at National Agriculture Research Center Islamabad during 2010-2011. Highly significance variation was observed for most traits of the hybrids evaluated. It was also invented to compare their performance in order to identify and select hybrids with enhanced potential for growth and yield in humid sub-tropical climate. The highest number of big size (>55mm) tubers per meter^2 (5.77) was produced by clone G-136 while clone D-46 and A-12 produced minimum number (2) of big tubers per meter^2 however average big tuber weight (177.06 g) was recorded in N-10, whereas the maximum medium size tubers (20.97) per meter^2 were obtained from potato clone A-12, however, potato genotypes N-10 produced least number of medium tubers (7.36). Maximum weight of medium tubers was in I-32 (86.58g) and minimum weight was in D-46 (45.49 g). The maximum numbers of total tubers (45.27) per meter^2 were recorded in clone I-23. The maximum average weight of total tubers was 89.46 g in clone I-32. Potato clone I-32 produced maximum percentage of marketable tubers with 94.76% followed by Clone O-17, F-24 and N-10 with 94.42 %, 93.71 % and 92.58 % respectively. Although clone I-23 produced more number of tubers than that of the I-32 but the marketable tuber percentage was less in the clone I-23. So, this study recommends the clones O-17, I-30, I-32, G-128, K-139 and F-24 for potato cultivation in humid subtropical conditions during autumn season for maximum yield.

Key words: *Solanum tuberosum,* Potato, Yield, Varieties; Hybrid; Autumn; Ecological.

INTRODUCTION

Potato crop in Pakistan is cultivated in a wide range of agro-ecological zones and ranks third among food crops following wheat and rice (GOP, 2012). Potato is highly nutritious food being in itself close to a well-balanced diet. It is the highest producer of energy per hectare of any food crop grown. During the past decade, potato has emerged as the highest yielding cash crop in Pakistan. It has gained economic importance in the country and there is rapid increase in area under its cultivation (Farooq *et al.,* 2002). In Pakistan potato is cultivated over 0.184 million hectares with production of 3.39 million tones (GOP, 2012). Its average yield is 18.42 tones per hector which is far less as compared to other potato growing countries. There are number of factors responsible for its low productivity. One of the most important factors is that potato crop in those temperate countries is grown under long days and long growing season of 160-180 days. In contrast, major portion of the crop in Pakistan is grown in sub-tropical plains under short days and short growing season of 90 days (Pandey, 2007). So there is a need to evaluate such varieties which are heat tolerant, early bulking and resistant to late blight and viruses. Therefore a breeding program has been launched by NARC to develop new hybrids which are best suited to local conditions. This program was started with hybridizations among different pairs of parents to obtain true seeds from which the various hybrids were developed. In this study, some potato hybrids were evaluated to determine the nature and extend of variability in some economically important traits and compare their performance in order to identify and select high yielding hybrids suitable for cultivation in humid sub-tropical conditions.

MATERIALS AND METHODS

This research work was completed at National Potato Programme, Horticulture Research Institute, National Agriculture Research Center Islamabad. Fifty new hybrids with three check varieties Cardinal, Desiree and Diamant were evaluated in replicated trial under field condition. The trial was conducted following three replications/block. Each plot had five rows, 75 cm apart and 4 meter long (with an area of 15 m^2) where plant to plant distance were kept 20 cm. The recommended dose of fertilizer i.e. nitrogen 250 Kg, phosphorus 125 Kg and potassium 125 Kg per hectare were applied by placement method. Half nitrogen was applied at the time of planting and remaining was applied at earthing up (Malik, 1995). Crop was visited regularly throughout the growing season and plant protection measures were also adopted as and when required. Hybrids A-3, A-12, A-15, A-45, B-1, B-2,

B-4, C-36, C-69, D-26, D-37, D-40, D-41, D-45, D-46, F-1, F-7, F-19, F-21, F-24, F-86, G-92, G-119, G-126, G-128, G-132, G-136, G-138, G-147, G-148, H-31, H-33, H-42, H-44, H-57, I-23, I-28, I-30, I-32, J-20, J-56, K-139, L-32, L-95, M-33, M-66, N-4, N-10, O-17 and P-5 were evaluated. Different parameter studied included (i) large size tubers (>55 mm) and their weight (g), (ii) medium size tubers (35-55 mm) and their weight (g), (iii) small size tubers (<35 mm) and their weight (g), total number and weight of tubers, (iv) marketable yield (%), (v) non-marketable yield (%), (vi) yield tone/ha, (vii) tuber characteristics *i.e.* tuber shape, eye depth, tuber skin color, flesh color, General appearance as described by Wooster and Farooq 1995).

Statistical analysis: The data recorded were analysed for variance following the methods used by Steel *et al.* (1997). Analysis of data was done using MSTATC, 1991 under Randomized Complete Block Design and comparison was made utilizing Duncan's Multiple Range (DMR) test at 5 percent probability level (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

i) Large size tubers (> 55mm) per m^2 and average weight of $tuber^{-1}$ (g): The highest numbers of large tubers (5.77) were recorded in G-136, G-138, H-57 and N-10 which were statistically at par and differed significantly from rest of the hybrids tested during this study. Minimum numbers of large size tubers were recorded in D-46 and A-12 with 2 tubers each. Data concerning average weight of large size tubers of different varieties have been presented in table 1. Results were statistically significant among hybrids during the year; however average weight of tubers ranged from 177.06 g in N-10 to 142.22 g in A-12. A higher quantity of large size tubers might be due to fast plant emergence and better plant growth (Patel *et al*., 2008). Similar findings were reported in case of tuber weight by Singh and Ahmad (2008). Varieties and lines differed for different characteristics (Kumar *et al*., 2004). Patel *et al.* (2005) also validated this study that numbers of large size tubers were different in case of varieties.

ii) Medium size tubers (35-55mm) per m^2 and average tuber weight (g): The more number of medium size tubers (20.97) were obtained by potato clone A-12, followed by F-24 (20.19), F-23 (18.39), A-45 (18.25) and Cardinal (18.17). However, potato genotypes N-10 produced least number of medium tubers (7.36) followed by G-119 (7.69), F-21 (8.03) and G-132 (8.81) (Table 1). Data concerning average weight of small tubers were presented in table 1. Maximum weight was recorded for I-32 (86.58 g) followed by H-42 (85.44 g), K-139 (79.13 g) and F-84 (76.8 g) and minimum weight were in D-46 (45.49 g) followed by Diamant (54.89 g), I-32 (58.39 g) and A-2 (58.59 g). A number of developmental factors viz., vegetative growth, genotypes, plant growth rate and emergence time might be responsible for this variation in number of medium size tubers. Higher number of tubers per plant may be due to vegetative growth (Kumar *et al*., 2006). Similarly, Patel *et al*. (2008) explained that rapid plant emergence and better plant growth resulted in higher number of medium size tubers.

iii) Small size tubers (< 35mm) per m^2 and average tuber weight (g): The results showed significant differences among various potato hybrids for number of small size tubers and average weight as given in table 1. Genotypes F-23, A-12, F-7, Diamant, F-1 and D-37 gave significantly higher number of small size tubers having 22.41, 17.86, 16.87, 16.86, 16.31 and 15.54 tubers respectively. On the other hand, I-32, N-10, G-147, G-132, F-21 and G-92 had significantly lower number of small size tubers viz., 4.73, 5.95, 6.08, 6.17, 6.17 and 6.84 tubers respectively. Results were statistically significant among hybrids, however average weight of tubers ranged from 25.37 g in G-119 to 14.5 g in O-17. Foliage growth, genetic makeup and maturity might have caused the variation in average weight of small size tubers among genotypes. One of the essential factors that affected the percentage of different tuber sizes was vegetative growth and stem numbers. Azad *et al.*, 1997 reported that varieties produced different number of tubers. More number of small size tubers might be due to the higher vigor of plants coupled with delayed maturity (Sharma and Singh, 2009). Similarly more number of small size tubers might be due to effect of growth attributes (Patel *et al*., 2008).

iv) Total tubes in $1m^2$: The results regarding total number of tubers (table 1) showed that the differences were significant for total tubers per m^2 among potato hybrids. Total numbers of tubers were significantly higher in I-23, A-12, Diamant, F-1, Cardinal and D-37 having total tubers value like 45.24, 40.83, 37.27, 36.82, 35.98 and 35.84 tubers respectively. Minimum number of total tubers was 19.09, followed by 19.44, 19.57, 19.67, 20.20 and 20.65 respectively in N-10, F-21, I-32, G-147 and G-132. The reasons for variation in total tuber number might be due to genetic development and growth. The results are in accordance with the findings of Singh and Ahmad, 2008, who reported variation due to foliage and tuber initiation. Pandey *et al*., 2008 also reported that varieties differed for total number of tuber at 90 days after planting. Sufficient growth (stem number and plant height) had positive contribution towards tuber number (Luthra *et al*., 2005).

v) Average weight of total tuber (g): Results given in table 1 described that average weight of total tubers differed significantly among genotypes. Heavy

tubers were found in the genotypes i.e. I-32, N-10, H-42, L-95 and K-139 having average tuber weight 89.46 g, 83.8 g, 79.41 g, 77.79 g and 77.78 g respectively. Minimum average tuber weight of 43.37 g, 46.20 g, 46.71 g, 48.51 g and 48.97 g were observed in D-26, A-12, D-46, A-3 and I-23 respectively. The difference may be attributed to genotypes, adequate vegetative growth and disease incidence. The similar findings were reported by Patel *et al*., 2008 that more average tubers weight may be due to fast plant emergence and better plant growth.

vi) Marketable yield (%) (tubers >35mm): Results pertaining to the marketable yield percent (table 1) showed significant difference among the potato genotypes. Significantly higher percentage of marketable grade yield manifested by I-32 followed by O-17, F-24 and N-10 with the values of 94.76 %, 94.42 %, 93.71 % and 92.58 % respectively, while the minimum marketable yield was shown by I-23 followed by F-7, D-26 and D-46 with values of 80.24 %, 80.88 %, 81.86 % and 82.28 % respectively. The variation in the marketable yield of potato genotypes may be due to genotypic/varietal factor. Similar results reported by Pandey *et al*. (2006), Marwaha *et al*. (2007) and Kumar *et al.* (2008) that different varieties had significant influence on marketable yield

vii) Non-marketable yield (%) (tubers <35mm): The results pertaining to non-marketable yield percentage of genotypes are presented in table 1. The results showed that varieties differed significantly for non-marketable yield percentage. The significantly higher percentage of non-marketable yield like 19.76 %, 19.2 %, 18.14 % and 17.72 % were noticed by I-23, F-7, D-26 and D-46 respectively. Significantly lower percentages of non-marketable yield were given by I-32, O-17, F-24 and N-10 with values of 5.23 %, 5.58 %, 6.29 % and 7.42 % respectively. The variation in non-marketable yield percentage of the genotypes may be due to crop vigor / maturity, inherent ability of potato genotypes and number of tubers per plant. More yield of small size tubers may be attributed due to higher number of tubers as well as effect of other growth attributes (Patel *et al*., 2008). Stem number and plant height may strongly influence the non-marketable yield of potato cultivars (Arsenault and Christie, 2004).

viii) Yield (t ha^{-1}): The results pertaining to yield (t ha^{-1}) of different potato hybrids (Table 1) showed that yield differed significantly among different potato genotypes. Results revealed that significantly higher yield was observed in K-139, F-24, F-23 and Diamant with 22.98, 22.47, 22.16 and 21.41 t ha^{-1} respectively. While significantly low yield was recorded in B-1 followed by G-147, A-3 and D-40 with values of 12.56, 13.58, 14.1 and 14.42 t ha^{-1} respectively. Patel *et al* (2008) reported that the higher tuber yield may be due to prompt plant emergence and better plant growth. It may also be due to the higher number of tubers per plant as well as combined effect of all other growth and yield attributes. Longer growing periods/crop maturity affects yield of potato varieties (Wang *et al.,* 1995). The increase in yield was mainly owing to the higher number of tubers/plant and tuber size (Mehdi *et al*., 2008)

Tuber Characteristics: Tuber shape, skin color, flesh color, eye depth, and general appearance are the distinctive qualities of potato for commercial interest regarding table use and processing. Thus these characters influence consumer choice. From consumer point of view the most important characters are eye depth, tuber shape and general appearance (Pandey *et al*., 2000). He also reported that in Pakistan, India and Bangladesh generally red potatoes are preferred. Abbasi *et al.,* (2004) reported that skin color is genetically controlled attribute. Skin color is controlled by genetic factors (Anwer, 1982). Tubers round to oblong in shape are considered suitable for chip making and long oval to very long oval shaped tubers are considered best for making French-fries (Pandey *et al.,* 2008). Consumers like potatoes which have shallow to medium shallow eyes because shallow eyes reduce the peeling losses (Kabira and Lemaga, 2006).

Table 1. Tuber grade and weight.

Clone	Big tubers (>55mm) in 1 m^2	Ave. weight (g) of big tubers	Medium tubers (35-55mm) in 1 m^2	Ave. weight (g) of medium tubers	Small tubers (<35mm) in 1 m^2	Ave. weight (g) of small tubers	Total tubers in 1 m^2	Ave. weight (g) of total tubers	Marketable yield (%)	Non-marketable yield (%)	Yield t/ha
A-3	3.78	152.78	10.22	58.597	14.89	14.65	28.89	48.51	84.56	15.44	14.1
A-12	2.00	142.22	20.89	61.003	17.78	17.927	40.67	46.203	82.98	17.02	18.82
A-15	3.78	153.33	15.55	68.553	14.89	20.087	34.22	56.957	84.64	15.36	19.58
A-45	4.22	150	18.22	60.927	11.11	16.9	33.55	57.603	90.33	9.673	19.29
B-1	2.67	150	11.11	63.907	6.67	20.963	20.45	60.81	88.58	11.42	12.56
B-2	4.44	144.13	12.22	61.663	12.45	21.317	29.11	57.073	84.11	15.89	16.68
B-4	4.22	156.82	15.11	70.793	10.67	21.383	30.22	65.31	88.27	11.73	19.64
C-36	4.89	158.45	10.89	62.277	9.55	15.253	25.33	62.973	90.79	9.207	15.93
C-69	2.89	157.5	15.33	73.967	13.11	21.15	31.55	59.617	85.14	14.86	18.78
D-26	2.89	161.67	17.11	45.49	15.11	18.237	35.11	43.37	81.86	18.14	15.2
D-37	4.22	156.67	16.00	70.673	15.55	19.237	35.78	58.573	85.77	14.23	20.99
D-40	2.22	162.22	16.22	58.647	7.55	17.317	26.00	55.633	90.99	9.01	14.42
D-41	4.22	160.63	16.45	61.813	10.22	19.33	30.89	61.007	89.37	10.63	18.95
D-45	4.22	157.54	10.45	72.46	7.33	17.76	22.00	70.823	91.7	8.297	15.55
D-46	2.00	153.33	15.78	61.347	15.33	17.843	33.11	46.71	82.28	17.72	15.44
F-1	3.56	164.11	16.89	64.57	16.22	16.803	36.67	53.123	85.87	14.13	19.57
F-7	3.78	156.11	11.78	66.857	16.89	19.333	32.45	52.527	80.8	19.2	17
F-19	4.89	165.89	11.78	65.487	10.45	19.463	27.11	65.96	88.66	11.34	17.87
F-21	5.33	162.5	8.00	65.157	6.00	20.543	19.33	77.77	91.77	8.23	15.12
F-24	4.44	160.71	20.22	68.887	7.11	19.63	31.78	70.593	93.71	6.29	22.47
F-84	3.56	158.78	16.00	76.8	8.45	21.097	28.22	70.31	90.88	9.123	19.76
G-92	3.11	165	16.00	62.177	6.67	18.797	26.00	63.243	92.22	7.777	16.47
G-119	5.11	151.79	7.55	69.073	8.00	25.373	20.67	72.683	86.63	13.37	15.11
G-126	4.22	160.32	9.11	70.877	8.00	19.743	21.33	69.093	89.2	10.8	14.75
G-128	3.78	155.78	12.89	74.5	10.45	18.59	27.11	64.58	88.96	11.04	17.59
G-132	5.11	152.26	8.67	63.853	6.00	21.757	20.22	73.4	90.91	9.093	14.8
G-136	5.78	149.4	9.78	61.79	8.00	20.373	23.55	69.363	89.98	10.02	16.41
G-138	5.78	151.67	9.33	73.093	6.89	19.257	22.00	76.557	92.09	7.913	16.94
G-147	4.44	153.57	8.89	62.063	6.00	18.993	19.55	69.497	91.38	8.62	13.58
G-148	4.89	157.98	9.11	68.26	10.22	19.437	24.22	65.767	87.59	12.41	15.93
H-31	5.11	151.79	11.78	62.587	8.45	19.757	25.33	66.37	89.96	10.04	16.84
H-33	5.56	157.5	11.33	71.14	10.45	21.073	27.55	69.347	88.36	11.64	19.07
H-42	4.44	153.49	13.78	85.44	7.11	21.707	25.78	79.417	92.23	7.767	20.19
H-44	3.11	156.17	15.55	62.03	14.89	20.283	33.55	52.26	82.95	17.05	17.61
H-57	5.78	159.72	13.55	71.313	10.45	20.92	29.78	70.79	89.71	10.29	21.17
I-23	4.44	157.62	18.45	58.397	22.22	19.55	45.11	48.977	80.24	19.76	22.16

I-28	3.56	159.44	12.00	74.383	6.67	20.287	23.11	71.29	91.31	8.687	15.99
I-30	3.56	155.56	12.67	67.067	12.67	18.63	29.11	56.507	85.4	14.6	16.47
I-32	4.44	170.95	10.45	86.583	4.67	19.493	19.55	89.46	94.76	5.237	17.6
J-20	5.56	170.56	8.89	62.957	8.67	17.263	23.11	71.553	90.86	9.137	16.52
J-56	2.89	172.5	15.11	68.657	11.33	18.007	29.55	58.96	88.2	11.8	17.5
K-139	4.22	177.06	17.33	79.133	8.00	21.47	29.55	77.783	92.54	7.463	22.98
L-32	3.56	165.11	16.89	63.243	11.33	19.437	31.78	59.013	88.27	11.73	18.81
L-95	5.11	172.98	10.22	76.733	7.78	17.72	23.11	77.79	92.21	7.79	18.09
M-33	2.67	162.5	14.00	68.93	7.11	20.1	23.78	64.693	90.67	9.333	15.4
M-66	5.56	168.98	14.45	64.303	12.45	17.907	32.67	64.51	89.36	10.64	21.02
N-4	4.89	171.91	16.45	65.81	9.11	17.927	30.67	68.26	92.04	7.963	20.96
N-10	5.78	175	7.33	63.863	6.00	19.88	19.11	83.8	92.58	7.423	16
O-17	4.44	171.99	17.33	68.36	8.00	14.503	29.78	69.37	94.42	5.583	20.7
P-5	4.22	173.41	16.00	59.283	12.00	16.56	32.22	58.137	89.37	10.63	18.8
Cardinal	5.56	173.01	18.22	67.283	12.22	22.43	36.00	68.613	88.95	11.05	19.63
Desiree	4.89	173.1	14.00	68.153	11.55	20.12	30.67	66.653	88.5	11.5	20.3
Diamant	5.56	176.34	14.89	54.583	16.89	20.627	37.33	57.403	83.7	16.3	21.41
LSD (0.05)	0.57	10.21	1.83	8.21	1.45	1.58	2.28	4.6	10.61	1.61	1.35

Table 2. Tuber characteristics of 53 genotypes

Cross & No.	Skin Color	Shape of Tuber	Eye Depth	Flesh Color	Gen. App.
A-3	Red	Oval	deep	Cream	6
A-12	White	Oval	Med deep	Yellow	6
A-15	Red	Round	Med deep	Cream	5
A-45	Red	Round to short oval	med deep	Cream	6
B-1	White	Oval	shallow	Yellow	7
B-2	Red	Round to short oval	Med deep	Cream	7
B-4	Red	Oval	Med deep	Yellow	6
C-36	Red	Round to short oval	Med deep	Cream	7
C-69	Red	Oval	shallow	Yellow	7
D-26	Red	Round	deep	Cream	5
D-37	White	Round	deep	Cream	5
D-40	White	Round to short oval	Med deep	Cream	6
D-41	Red	Oval	shallow	Yellow	7
D-45	Red	Oval	Med deep	Yellow	7
D-46	White	Long oval	Med deep	Cream	6
F-1	White	Round	Med deep	Cream	6
F-7	Red	Round	Med deep	Cream	6

F-19	Red	Oval	Med deep	Yellow	6
F-21	Red	Long oval	Med deep	Cream	6
F-24	Red	Oval	med deep	Cream	6
F-84	Red	Oval	Med deep	Cream	6
G-92	Red	Oval	Med deep	Yellow	6
G-119	Red	Oval	shallow	Yellow	8
G-126	Red	Oval	Med deep	Cream	5
G-128	Red	Oval	Med deep	Cream	6
G-132	Red	Oval	Med deep	Yellow	6
G-136	Red	Oval	shallow	Yellow	7
G-138	Red	Oval	Med deep	Yellow	6
G-147	Red	Oval	Med deep	Yellow	6
G-148	Red	Oval	Med deep	Yellow	6
H-31	Red	Long oval	Med deep	Yellow	7
H-33	Red	Oval	shallow	Yellow	7
H-42	Red	Long oblong	deep	White	6
H-44	Red	Long oblong	shallow	Yellow	8
H-57	Red	Oval	Med deep	Yellow	7
I-23	Red	Long oval	deep	Yellow	5
I-28	Red	Oval	shallow	Cream	7
I-30	Red	Oval	shallow	Yellow	7
I-32	Red	Long oval	shallow	Yellow	8
J-20	Red	Round	Med deep	Cream	6
J-56	White	Long oval	shallow	Yellow	7
K-139	Red	Long oval	Med deep	Yellow	6
L-32	Red	Oval	Med deep	Yellow	7
L-95	Red	Oval	Med deep	Cream	7
M-33	White	Oval	Med deep	Cream	6
M-66	Red	Round	Med deep	Yellow	5
N-4	Red	Oval	Med deep	Cream	6
N-10	Red	Oval	Med deep	Cream	6
O-17	Red	Round	shallow	Yellow	7
P-5	White	Round	very deep	Cream	5
Cardinal	Red	Oval	Med deep	Yellow	7
Desiree	Red	Oval	shallow	Yellow	7
Diamant	White	Oval	shallow	Yellow	7

Note: Eye depth was recorded as shallow = 0.1-0.2 mm, medium = 0.2-0.6 mm and deep = >0.6

Score for the general appearance was based on the attractiveness of the sample between 1 and 9 where 1= very unattractive and 9= very attractive.

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