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Identification of heat tolerant, virus resistant candidate potato varieties for cereal based cropping system through participatory varietal selection approach

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Abstract— *12 heat tolerant, low tropical virus resistant potato CIP clones were evaluated to select candidate varieties that can be planted 15-30 days earlier than normal season in north Indian plains of Haryana. Regarding this research trials were conducted in three districts Karnal, Narnaul and Sirsa in rabi (winter) season of 2021. Out of 12 clones, 11 are red skin whereas clone 4621 has white skin tubers. Kufri Pukhraj, Kufri Lima, Kufri Khyati and one red skin variety Kufri Uday were planted as control. The experiments were planted in randomized block design with three replications. Planting was done in the first week of October almost 20 days earlier than normal season planting. Trials were dehaulmed at 75 days after planting in all the locations. Morphological and yield parameters were recorded and statistically analysed. In all the locations, the highest marketable and total tuber yields were recorded in variety K. Lima. It was statistically at par to clone 4611, 4620, K. Pukhraj and clone 4613. Among the locations, Sirsa was found most suitable place for table potato cultivation followed by Narnaul and Karnal. Two clones 4614 and 4616 found suitable for processing. Participatory varietal selection for tuber yield and market acceptability was done at Sirsa however, organoleptic test was conducted at Sirsa and Narnaul. Based on yield and market acceptability, K. Lima was preferred by stakeholders followed by clone 4621 and 4611. Among clones, 4621 was preferred by stakeholders for its good taste.*

Keywords— ***Potato clones, locations, heat tolerant, Early maturity, Participatory varietal selection, organoleptic test***

I. INTRODUCTION

Potato is the third major food crops consumed in India. Farmers are shifting to intensive cropping system by growing short duration varieties of different crops. Besides this, they are always in search of early season varieties to fetch premium price by selling the produce early in the market. Early harvest also gives a window for another winter crop such as winter wheat or vegetables. Being a cash crop, potato generates good income in a short period. Most of the farmers cultivate potato for table purpose. Limited farmers go for seed production or contract farming. In the last few years the crop is facing climate challenges such as unseasonal rains and high temperature during planting. Development of climate resilient short duration potato varieties with high yield and disease resistance are the demands of farmers. Again, selection of the variety with

stable performance over the locations is a challenge for a Breeder. Most of the genotypes behave differently over the environments. Therefore, it is essential to conduct location specific adaptation trial to identify suitable potato variety/varieties [1]. It is very important to identify and select location specific genotypes/clones, which have high yield potential with short growing period [26]. To assess the agronomic behavior of the genotypes, it is necessary to measure the relative stability of the genotypes submitted to all the predominant environments [25]. Knowing the magnitude of the Genotype x Environment interaction allows assessing the stability of the cultivars in the range of environments, in which they want to be introduced, as well as the productive potentials and limitations of these in the localities [4]. The interaction is a matter of relevance since it is one of the determining factors in the selection and recommendation of cultivars [2]. It highlights the importance of the environmental effect on adaptation and varietal behaviour, also increases the efficiency of genotype improvement [6]. Besides this, participation of stakeholders in the selection of candidate varieties facilitates acceptability of most suitable clones liked by stakeholders as per their choice [19]. Keeping all these aspects in view, 12 heat tolerant clones of potato were imported from International Potato Center (CIP), Lima (Peru) for evaluation under heat stress conditions.

II. MATERIALS AND METHODS

12 heat tolerant, low tropical virus resistant potato clones were evaluated at three Horticulture Centers of Haryana: Potato Technology Center, Karnal; Center of Excellence in Fruits, Sirsa and Integrated Horticulture Development Center, Narnaul during winter season of 2021. Among the locations, Karnal has mild climate with fertile soil. Sirsa and Narnaul are comparatively warmer but gets good sunny days with sandy-loam soil. 3 white skin (K. Lima, K. Khyati and K. Pukhraj) and one red skin (K. Uday) varieties were planted as standard checks. All the experiments were conducted in randomized block design with 3 replications. To assess the earliness of clones, planting was done in first week of October about 20 days earlier than the normal planting. Dehaulming was done at 75 days after planting (DAP). Plot size was 4.8 sqm; 40 tubers were planted in each plot with 60 cm spacing between rows and 20 cm between tubers. Recommended dose of NPK was given in the form of urea, DAP and MOP. Half dose of N and full dose of P and K were applied as basal and remaining N was applied 25 days after planting followed by earthing up. In Narnaul N was applied in three split doses: 3rd dose at 40 days after planting. Data for growth and yield were recorded and statistically analyzed. Sample tubers were supplied to PepsiCo lab for analysis of processing parameters.

Participatory varietal selection (PVS) exercise was conducted in Sirsa and Narnaul districts. Stakeholders including farmer, consumers and traders were invited for this exercise. Harvested tubers of each clone were heaped separately in the field,. A container is kept near each heap in which stakeholders put the grains. Each stakeholder was provided with six grains of kidney bean to select the best three varieties/clones. They were asked to put 3 grains in the jar for the 1st, 2 grains for 2nd and 1 grain for 3rd choice varieties/clone. After the exercise, grains were collected from the containers and counted separately for each variety/clone and ranking was given to clones/varieties based on number of grains. Clones/varieties having a greater number of grains was considered the preferred varieties.

Organoleptic test was also conducted to find out promising varieties based on taste. Under this test, 5 sample tubers of each clone were packed in hessian cloth bag separately and tagged to avoid mixing of clones. These tubers then boiled by putting all the bags in the water filled in a big container. Care was taken that the tubers were neither undercooked nor over cooked. Once the potatoes were cooked properly, tubers of each clone were kept in the plates, hiding the original number and an arbitrary number was marked on the plate. These tubers were peeled and cut into small pieces for tasting. Volunteer farmers/ stakeholders were involved in organoleptic evaluation of the clones. Each stakeholder was asked to taste the sample of every clone and the observations were classified as poor, good and excellent and were written down on a prescribed format, by the participants. Observations were presented through graphical data. The characteristics of the clones were compared separately for each location.

III. RESULTS

3.1 Morphological characters of clones

Morphological characters like plant vigour and plant habit were recorded at 60 days after planting and ranked into 1-5 scale. Based on the data depicted in Table 1, maximum vigour was recorded in clone 4609, 4620, 4621 and check varieties K. Lima and K. Pukhraj. Regarding plant habit clone 4613 showed compact growth followed by 4611, 4621 and K. Lima. Rest of the clones were showing medium to disperse plant growth.

3.2 Plant senescence

Plant senescence was recorded at 75 days, just before dehaulming to find out the early maturing clones. Data was recorded in 1-5 scale indicated very green to dry leaves.

Clones 4615 showed maximum senescence followed by K. Pukhraj and K. Uday.

3.3 Morphological characters of tuber

Tuber shape, skin colour, flesh colour and eye depth were recorded at the time of harvesting and presented in Table 1. The data reveals that most of the clones had red skin tubers except clone 4621 and variety K Lima, K Pukhraj and K Khyati. All the clones/varieties had shallow eyes except 4615 which had medium deep eyes. Regarding flesh colour, clones 4610, 4611, 4613, 4615 and 4617 contained white flesh whereas rest of the clones had yellow flesh colour.

Table 1 Morphological parameters of heat tolerant clones

CIP No.	CPRI No.	Plant Vigor	Plant habit	Senescence	Tuber Skin Colour	Tuber Shape	Tuber Eyes	Tuber Flesh Colour
302476.108	**4609**	5	2	1	R	OB	S	Y
304350.1	**4610**	4	2	3	LR	OB	S	W
304350.118	**4611**	4	4	1	R	O	S	W
304350.95	**4613**	4	5	3	R	OB	S	W
304366.46	**4614**	4	2	2	LR	R	S	Y
304380.19	**4615**	4	2	5	R	R	MD	W
309068	**4616**	3	3	3	R	R	S	Y
309105.41	**4617**	4	2	3	LR	OB	S	W
309117.115	**4618**	4	2	3	LR	O	S	Y
309118.5	**4619**	4	2	2	LR	OB	S	Y
396311.1	**4620**	5	2	1	R	O	S	Y
398208.505	**4621**	5	4	2	W	O	S	Y
	K Uday	4	2	4	R	OB	S	Y
	K. Lima	5	4	1	W	O	S	W
	K. Pukhraj	5	2	4	W	O	S	Y
	K. Khyati	4	2	3	W	O	S	Y

Legend: **Plant vigour:** 1-least,5-most; **Plant habit:** 1-disperse, 5-compact; **Senescence:** 1-least,5-most, **Skin Colour:** R-red, LR-light red, W-white; **Flesh colour**: Y-yellow, W-white, **Shape:** R-round, OB-oblong, O-oval; **Eyes:** D-Deep, MD-medium deep, S-shallow

3.4 Marketable and total tuber yield

The data presented in Table 2 indicate that significant differences were observed among the clones with respect to marketable and total tuber yield. In all the locations, the highest marketable and total tuber yields were recorded in variety K. Lima. It was statistically at par to clone 4611, 4620, K. Pukhraj and clone 4613. Significant difference was also recorded mong the locations for marketable and total tuber yield. Sirsa was found most suitable location for potato cultivation followed by Narnaul and Karnal. Similarly, interaction of clones and locations showed significant influence on marketable and total tuber yield. Maximum marketable tuber yield was recorded in clone 4611 followed by 4620 in Sirsa. However, the minimum yield was recorded in clone 4616 in Karnal. The total tuber yield was recorded highest in K. Lima followed by K. Khyati and clone 4620 in Sirsa, while it was found lowest in clone 4616 in Karnal.

Table 2. Marketable and total tuber yield of heat tolerant clones in Karnal, Sirsa and Narnaul districts of Haryana

Clones/Varieties	Marketable yield (T/Ha)				Total tuber's yield (T/Ha)			
Location	**Karnal**	**Narnaul**	**Sirsa**	**Mean C**	**Karnal**	**Narnaul**	**Sirsa**	**Mean C**
4609	20.2	22.8	26.7	**23.3**	20.8	27.3	29.9	**26.0**
4610	19.3	18.0	24.2	**20.5**	19.6	19.1	26.3	**21.7**
4611	24.6	31.0	31.7	**29.1**	24.8	32.1	32.6	**29.8**
4613	26.7	30.1	25.5	**27.4**	27.0	32.7	27.5	**29.1**
4614	19.6	18.7	22.3	**20.2**	20.1	19.4	24.0	**21.2**
4615	21.5	25.7	28.7	**25.3**	21.8	27.8	31.5	**27.0**
4616	15.9	19.1	24.4	**19.8**	16.0	19.8	25.8	**20.5**
4617	20.6	22.9	17.2	**20.3**	20.9	24.4	19.2	**21.5**
4618	21.8	18.9	21.0	**20.6**	22.0	21.0	23.4	**22.1**
4619	23.1	17.6	27.2	**22.6**	23.3	19.1	28.9	**23.8**
4620	26.9	27.7	31.6	**28.7**	27.3	30.3	33.0	**30.2**
4621	30.7	23.4	22.8	**25.6**	31.2	27.6	26.3	**28.4**
K. Uday	17.1	27.9	30.9	**25.3**	17.3	29.1	32.3	**26.2**
K. Lima	31.3	27.4	31.3	**30.0**	31.6	30.0	33.5	**31.7**
K. Pukhraj	28.7	25.0	28.5	**27.4**	29.2	27.5	30.8	**29.2**
K. Khyati	25.9	22.6	30.0	**26.2**	26.5	24.4	33.3	**28.0**
Mean L	**23.1**	**23.6**	**26.7**		**23.4**	**25.6**	**28.7**	
LSD @ 5%	**C- 2.6**	**L- 1.1**	**C x L- 4.5**		**C- 2.64**	**L- 1.10**	**C x L -4.6**	

Legend: L-Location; C-clone/varieties; T/Ha- tonnes per hectare; LSD- least significant difference

3.5 Processing test

To assess processing attributes of clones and varieties, sample tubers were given to the processing company PepsiCo. Cook test, solid content and sugars test were done. The data presented in Table 3 shows that clone 4614 had highest gross solid content followed by 4618, 4615, 4616, 4619 and 4621. Total potato defects (TPOD) were recorded minimum in clone 4616. All the clones/varieties showed acceptable sucrose content for processing, however, dextrose sugar was beyond the acceptable limit.

Table 3. Processing parameters of heat tolerant clones measured by PepsiCo.

Sample No.	Solid %		Cook Test				YSI Analysis			
	FL Solid	Gross Solid	UC%	ID%	ED%	TPOD%	Suc g/l	Suc %	Dex g/l	Dex %
4609	14.68	17.69	29.0	11.0	20.0	60.0	0.346	0.074	0.244	0.052
4610	0.00	0.00	60.0	10.0	7.0	77.0	0.235	0.051	0.596	0.128
4611	0.00	0.00	100.0	0.0	0.0	100.0	0.123	0.026	1.690	0.363
4613	14.47	17.43	100.0	0.0	0.0	100.0	0.240	0.052	0.381	0.082
4614	16.07	19.36	60.0	20.0	4.0	84.0	0.350	0.075	0.464	0.100
4615	15.00	18.07	65.0	15.0	0.0	80.0	0.246	0.053	0.695	0.149
4616	15.00	18.07	16.0	14.0	17.0	47.0	0.319	0.069	0.315	0.068
4617	14.82	17.86	40.0	20.0	8.0	68.0	0.337	0.072	0.528	0.114
4618	15.36	18.51	100.0	0.0	0.0	100.0	0.251	0.054	0.802	0.172
4619	15.00	18.07	56.0	14.0	10.0	80.0	0.293	0.063	0.487	0.105
4620	14.29	17.22	100.0	0.0	0.0	100.0	0.289	0.062	0.576	0.124
4621	15.00	18.07	100.0	0.0	0.0	100.0	0.320	0.069	1.190	0.256
K. Uday	0.00	0.00	100.0	0.0	0.0	100.0	0.145	0.031	0.173	0.037
K. Pukhraj	0.00	0.00	100.0	0.0	0.0	100.0	0.153	0.033	0.871	0.187
K. Lima	0.00	0.00	36.0	20.0	4.0	60.0	0.235	0.051	0.234	0.050
K. Khyati	0.00	0.00	100.0	0.0	0.0	100.0	0.211	0.045	0.568	0.122

Legend: FL- Frito-lay, UC- undesirable colour, ED- external defects, ID- internal defects, TPOD- total potato defects, Suc- sucrose, Dex- dextrose, YSI- yellow springs instrument

3.6 Participatory varietal selection (PVS) for yield and acceptability

PVS for yield and varieties acceptability was done in Sirsa by making heaps of harvested tubers. Stakeholders selected their choice varieties based on market acceptability and yield. The results of this exercise revealed that stakeholders preferred K. Lima followed by 4621 and 4618 based on their attractive shiny tubers.

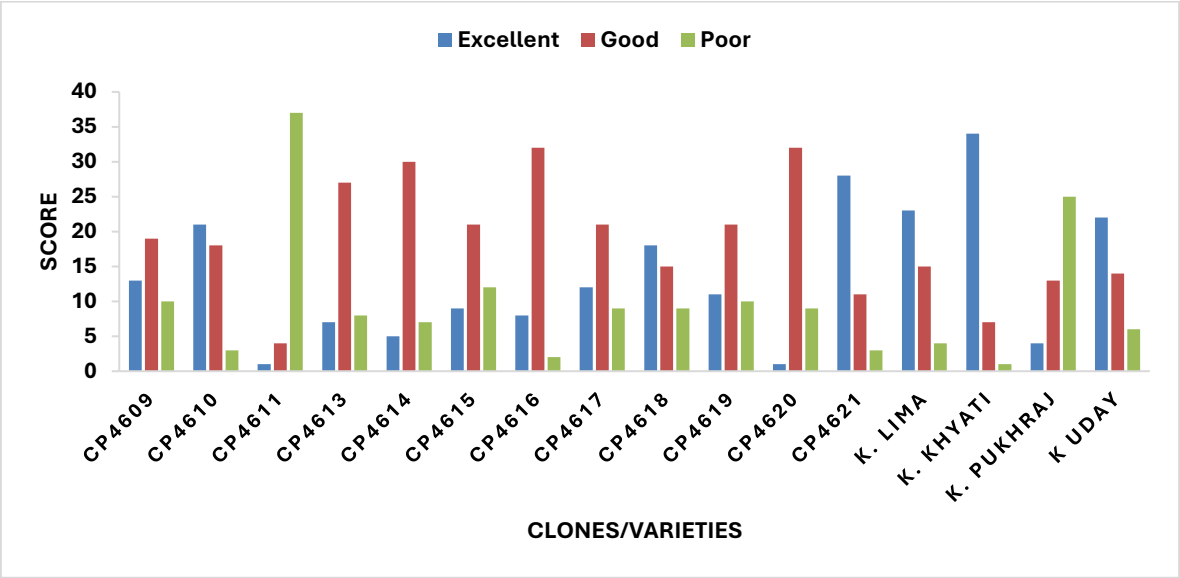
Table 4. Ranking of clones based on stakeholders' preference

Clone/variety	Score	Rank
4609	0	-
4610	11	IV
4611	18	III
4613	2	X
4614	0	-
4615	2	X
4616	0	-
4617	0	-
4618	5	VIII
4619	4	IX
4620	0	-

4621	24	II
K. Uday	8	VII
K. Lima	61	I
K. Khyati	5	IX
K. Pukhraj	10	V

3.7 PVS for organoleptic test

Organoleptic test was also done at farmer's fields in Sirsa and Narnaul to select the best variety based on taste. In Sirsa, K. Khyati received 1st rank by stakeholders followed by clone 4621 and K. Lima (Fig.1). However, in Narnaul clone 4621 was preferred followed by 4609 and 4618 (Fig. 2).



Fig, 1: Organoleptic test for taste of heat tolerant clones by stakeholders in Jodhka, Sirsa.

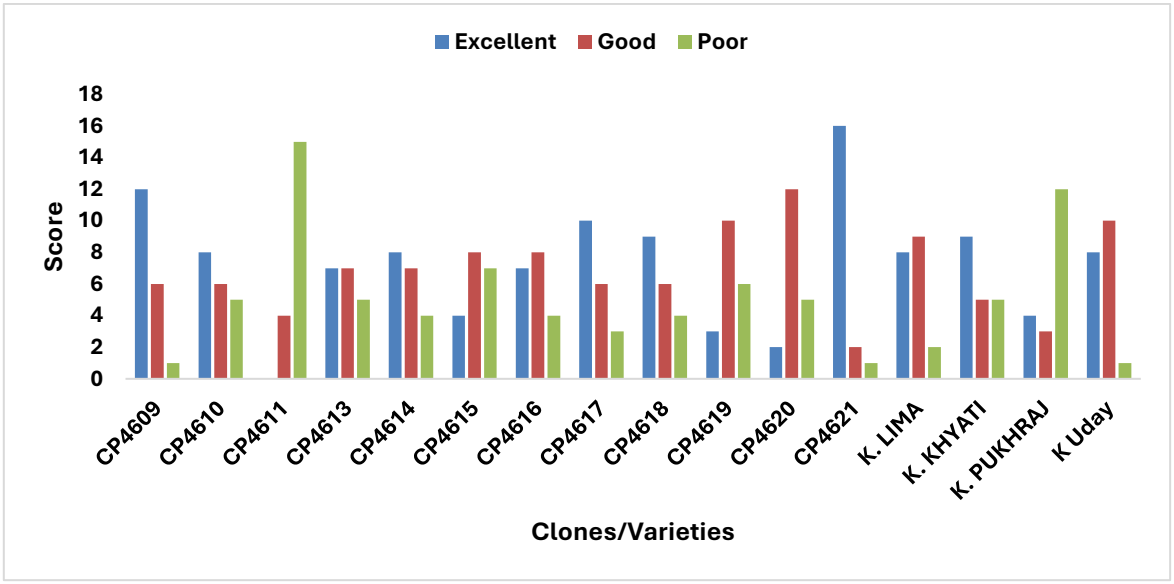


Fig. 2: Organoleptic test for taste of heat tolerant clones by stakeholders in Narnaul.

IV. DISCUSSIONS

4.1 Morphological characters of clones

Plant vigour and plant habit indicates the sturdiness of plant. However, it is not correlated with the tuber yield. Plants having more vigour translocate more food to the leaves rather than tubers consequently lesser yield. Compact growth is desirable as this prevent lodging in plants. Similar morphological variations on potato had been studied by previous researchers [9] and [10].

4.2 Plant senescence

Senescence of leaves defines crop maturity. It is a genetically governed character which also influences by management practices. Clones having early senescence indicated their earliness which is a most desirable character after yield as it enhances intensity of the cropping system. Senescence of leaf is an indicator of tuber bulking cessation and maturity [15] and [18].

4.3 Morphological characters of tuber

The shape, eye depth, skin and flesh colour of the tubers are genotypically governed and did not change much with the climate. However, soil impacts little on intensity of tuber colour, it becomes dull with the loose soil. The acceptability of tuber shape and colour of skin and flesh varies location to location. Similarly, deep eyes of tubers are not desirable as it requires more peeling. These distinctive quality parameters influence consumer's choice [19].

4.4 Marketable and total tuber yield

The significant variation in marketable and total tuber yield within the location might have been due to genotypic or varietal factor as reported by [7]. The moderate climate with maximum sunny days of Sirsa accelerate the photosynthesis and translocation of food consequently for fast bulking of tubers. In Karnal, foggy days during tuber bulking stage reduced photosynthetic rate and that reduced tuber yield. Similar finding of genotype-environment interaction was also reported by [3] and [12]. These reporting was also supported by [16].

4.5 Processing test

All the clones behaved differently with respect to processing parameters. Clones having high dry matter content, low sugars with good chip colour found suitable for processing. Similar findings were observed by [14] while evaluating different accessions for selecting parents for development of processing varieties. [13] were of the views that dry matter content determines the suitability of genotype for processing purposes and thus affecting chips yields, texture, flavour, oil content and processing efficiencies. Similar findings were recorded by [20] while evaluating potato clones for processing.

4.6 Participatory varietal selection (PVS) for yield and acceptability

PVS is an important exercise to assess and select the farmer's choice candidate varieties based on tuber appearance, taste and yield. Selection of a promising clone was strongly related to participant's decision on its organoleptic acceptance and probable logical decision for future adoption of a genotype for commercial cultivation [8] [17] and [5]. The choice can varies from location to location, in some region white skin tubers are preferred while in other areas consumers like red skin tubers. Processing industries demand big size round tubers for chips and oblong/long for french-fries. Farmers always need the varieties that show high performance for yield along with disease resistance, good storage and other essential agronomic traits having reliable superiority over a wide range of environmental conditions [21]. Stakeholders of Sirsa preferred clones having shiny white skin tubers with high yield. They do not like red skin tubers due to lesser acceptability in the market. The findings are in similarity with the findings of [12].

4.7 PVS for organoleptic test

The organoleptic test is important to avoid the failure of any high yielding variety at consumers' level based on taste. [11] were of the views that acceptability of the varieties varies region to region. This is consistent with the findings of [24] who evaluated the clones through organoleptic test by participation of stakeholders.

V. CONCLUSION

Based on above findings it can be concluded that on the basis of yield, variety K Lima and clones 4620, 4611, 4613 and 4621 performed well at selected three locations. Clone 4615 also had good yield with early maturity. Based on processing data, clones 4616 and 4614 were found to be within the acceptable limits. Considering the preferences of stakeholders under PVS exercise, clone 4621 and variety K Khyati were most preferred.

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