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Evaluation of Red & Purple Skinned Advance Clones Suitable for Eastern Indo-Gangetic Plains of India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted at ICAR Central Potato Research Institute, Regional Station, Patna, Bihar during the year 2021-2022 and 2022-2023 to evaluate 04 red skinned and 02 purple skinned Potato advance clones with 05 controls as popular potato varieties in confirmatory yield trials. The performance of advance clones was evaluated with respect to their yield and yield attributing traits, dry matter, nutritional status of the tubers. The experiment was planted in Randomized Block design with 03 replications, plant to plant distance was 20 cm and row to row distance 60 cm. The experiment was planted in two sets i.e. 75 days & 90 days duration crop. The potato clones PS/16-02 & PS/16-17 were selected on the basis of their remarkable high marketable tuber yield (26.29 and 22.45 t/ha in 75 days duration and 30.16 t/ha & 25.81 t/ha at 90 days duration crop respectively). The nutritional status of the tubers were high, tuber shape ovoid to round, colour purple (PS/16-02) & red (PS/16-17), shallow eyes and good organoleptic qualities after boiling and frying. The dry matter content of these selected advance clones were 20.17 & 20.42 respectively.

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The aim of the experiment was to evaluate the performance of advance clones for the above-mentioned traits and to select suitable advance clones for introduction in All India Coordinated Research Project on Potato.

Keywords: Advance clones; control varieties; dry matter; confirmatory yield trial; tuber yield; nutrients.

1. INTRODUCTION

Potato (*Solanum tuberosum* L) is starchy vegetable crop grown throughout the world. It is important vegetable crop accounted as third most important food crop after wheat and rice (Haverkort, A., 2009) important constituent of our diet. Potatoes were introduced in Europe during 1570s within a short span of time. This important vegetable gained popularity and spread to whole Europe as well as different parts of the world (Hawkes, J. G., & Francisco-Ortega, J., 1993, Pandey, S., et al., 2003). It yields higher nutritious food per unit space and time under favourable climatic conditions as compare to the other major food crops (Dalamu, S. K., 2019). That is very good source of carbohydrate, fibre, vitamins B6, C and minerals like iron, zinc, potassium, magnesium etc. The tuber dry matter, protein and energy make it extra ordinary as compared to other vegetables (Kabira, J. N., & Lemaga, B., 2003).

In eastern Indo-Gangetic plains of India the duration of potato crop ranges from 75-100 days and it includes early, medium and late maturing varieties. The red skinned varieties are more preferred in this region over white skinned potato varieties. The preference is due to the food habit having potato varieties suitable for '*bhujia*' (fried sabji) making. The crop is grown during *Rabi* season. The most preferred temperature for the growth of potato crop is 15-20°C with short photo period 10 to 12 hours a day from October to February (Hirdesh Kumar, B., 2003). The potato produces more energy and healthy food free from fats per unit area than other important food crops (Lutaladio, N., & Castaldi, L., 2009). This crop is decorated with most of the nutrients like carbohydrate, proteins, vitamins, minerals, and dietary fibres (Mulatu, E., 2005). Potato is cultivated throughout India under diverse Agro climatic conditions varying from temperate high hills to subtropical plains. It was introduced in our country during the beginning of 17th century by Portuguese traders as it was staple vegetable crop in the Europe. Nowadays, it occupies the rank of staple food crop in India and become a common household item. It is economic in price, good source of energy, available throughout the year. The crop is versatile in nature and able to fight with hunger and malnutrition. The importance of this vegetable awarded in the year 2008 as 'International Year of Potato' by United Nations to highlight the advantages of potatoes in global food security and poverty eradication (UN, 2021). In potato on weight basis, 80% is water, 2% is protein 18% is starch and minerals. The global potato production was 371.14 million tonnes. India approximately contributes 13% of global potato acreage with 48.56 million tonnes of production [FAOSTAT, 2019, 2020, 2022, Bonierbale, 2020, Cutter, E. G., 2018).

There is a need of time to develop nutrient rich varieties in order to fight with the hunger and malnutrition in human population especially children and lactating mothers. As we know that potato is a staple vegetable crop in our country. A number of varieties, e.g. Kufri Neelkanth, Kufri Lohit, Kufri Manik were released and they are rich in Anthocyanin, ascorbic acid, carotenoids and zinc and Iron. The work of developing advance potato clones which are nutrient rich through conventional breeding, hybridization followed by phenotypic selection from F_1 to F_1C_5. The aim of the study was to evaluate potato advance clones, which are superior over control varieties in different parameters like tuber yield, nutritional status of the tubers (Zn & Fe) with high dry matter, shallow eyes on the tubers and with coloured skin rich in anthocyanins and flesh rich in carotenoids etc.

2. MATERIALS AND METHODS

2.1 Planting Materials

The material in this study were 6 advance clones of potato namely PS/16-02, PS/16-17, PS/16-19, PS/16-20, PS/16-22 and PS/16-34 along and five control potato varieties Kufri Keshar, Kufri Lalit, Kufri Lohit, Kufri Manik and Kufri Neelkanth.

2.2 Location of Experiment

The experiment was conducted at experimental field of ICAR-CRPI RS Patna during the year 2021-22 & 2022-23. The advance clones were

planted as per the standard experimental design during *Rabi* season. The cropping season starts from planting during first fort night of November and ends during last week of February with the harvesting of the crop.

2.3 Experimental Design & Planting Details

The design of the experiment was randomized block design and the planting details are given below,

2.3.1 Field preparation

A well-prepared field is pre-requisite for conducting an experiment. In case of potato well-prepared field obtained by deep ploughing (20-25 cm deep) with soil turning plough followed by 2-3 cross harrowing and leveling. It plays very important role in obtaining good tuberization in the crop. Leveling helps in moisture retention in the field obtained from the retreating rainfall. If the retreating monsoon is weak then the crop can be sown by giving by pre-sowing irrigation (*palava*) or light irrigation just after planting of the tubers.

2.3.2 Seed size, seed rate and spacing

Tubers with 30 to 50 g weight are most suitable for conducting the experiment. In this experiment, whole tubers of above-mentioned size were planted on the ridges. The plant-to-plant distance was 20 cm and row to row distance was 60 cm. The experiment was planted in 3 replications, 4 rows each of 3m length (plot size 7.2m^2). A shallow irrigation is required for even germination of the crop just after planting of the tubers on the ridges.

2.3.3 Manure and fertilizers

Potato crop requires 180: 60:120 (N: P: K) :: 340 kg urea:130 kg DAP: 200 kg MOP for good tuberization and better yield. Half doses of Nitrogen with full dose of Potassium & Phosphorous were applied during land preparation as a basal dose. To maintain the level of micro fauna in the soil 22-25 tones/ha of well decomposed farmyard manure/compost is required in this crop. A healthy timely sown crop produces about 35 to 40 tones tubers per hectare (Chidda Singh, 2010, Gopal, J., 2015, Hassanpanah, D., and Hassanabadi, H. 2014).

2.3.4 Method of planting

The experiment was planted as per the layout. Tubers were planted on the ridges, made with the help of manual labours or tractor driven ridge-maker. The planting of potato tubers was done manually with the help of *khurpi* at a depth of 7-8 cm followed by covering of planted tubers with the soil and followed by light irrigation.

2.3.5 Inter culture operations

Inter culture operations play important role in this crop, timely operations help better tuberization in the crop. In this crop early stage weeds can be controlled by weedicide Oxflurofen 23.5% EC (500 ml/ha) spray during pre-emergence stage (Jansky, S. 2009, Jozani, S., 2003, Meltzer, H. V., 1992). Hand weeding was done 25 days after planting followed by application of remaining half dose of Nitrogen in the form of urea in side of the furrows. Earthing up operation was done after application of urea in order to get better tuberization in the crop. In this crop 4-5 irrigations at 10-15 days interval were given as per the requirement. To control the incidence of late-blight during month of December & January one prophylactic spray of Mancozeb 75WP followed by 2 sprays of Cymoxanil 8% + Mancozeb 64% WP were done. As sucking pest like aphids and white flies are the prime vectors for spread of viral diseases in this crop, were controlled by spray of Imidacloprid 17.8% SL, 45-50 days after planting.

List 1. Planting details

Planting details:	:	Crop Year 2021-22	Crop Year 2022-23
Experiment Name	:	Confirmatory Yield Trial-1	Confirmatory Yield Trial-2
Date of planting	:	15/11/2021	13/11/2022
Date of harvesting	:	23/02/2022 to 25/02/2022	21/02/2023 to 22/02/2023
No. of total entries	:	6	6
No. of selected hybrids	:	6	2
Duration	:	75 & 90 Days	75 & 90 Days
Plot size	:	7.2 m^2	7.2m^2
Reps.	:	3	3
Controls	:	5	5

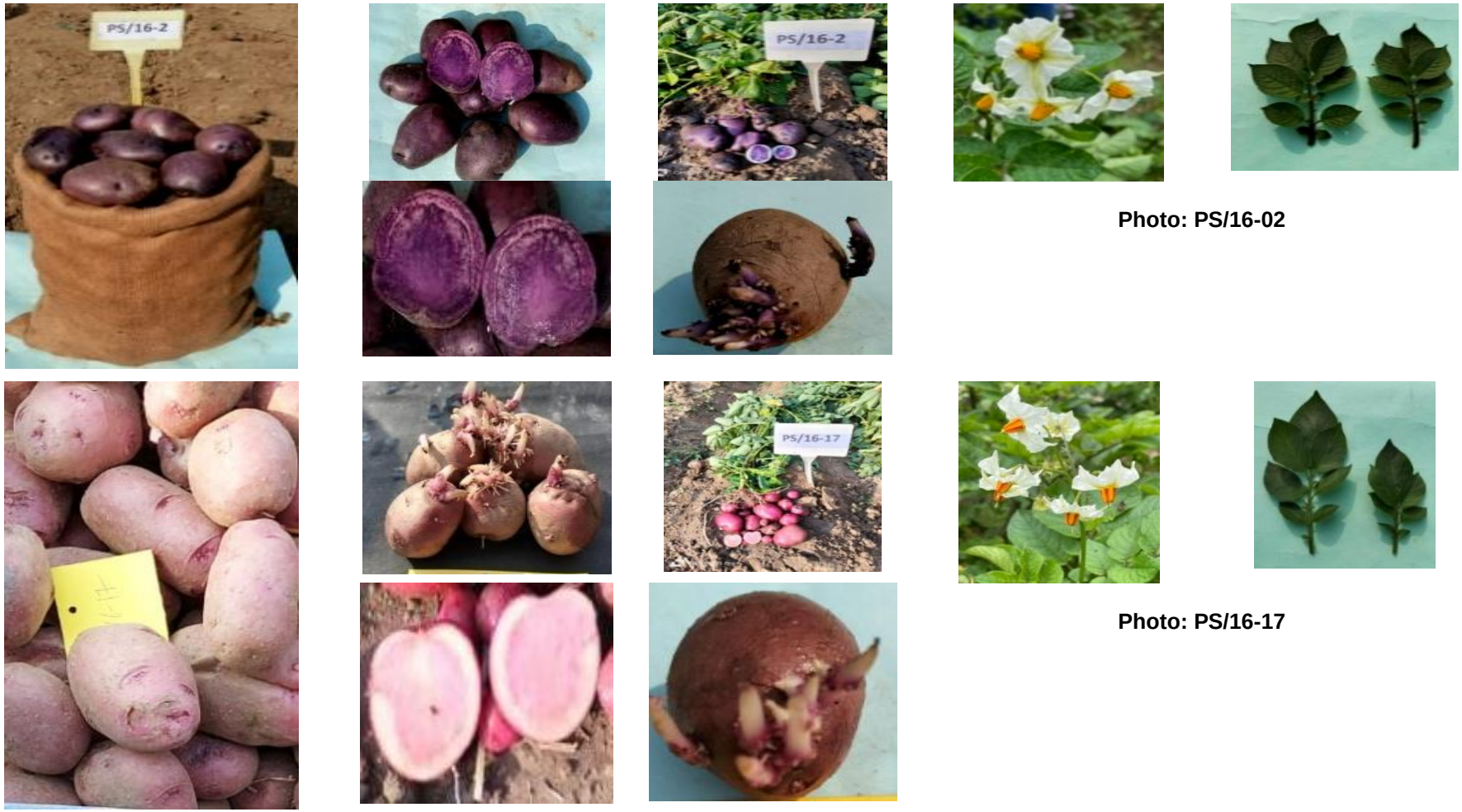

Photo: PS/16-02

Photo: PS/16-17

Photo 1. Red & purple skinned advance stage clones suitable for introduction in AICRP (P) trials

3. DATA COLLECTION AND RECORDING

The important observations were recorded for plant emergence (%), total tuber yield (t/ha), marketable tuber yield (t/ha), dry matter (%) and nutritional components were recorded at different physiological stages of the crop. The primary observations before planting of the crop were counting of tuber numbers required per plot were done. Then seed wt. per plot (in kg) was calculated at planting (Muthoni, J., 2014, Neele, A. E. F. (1991). Plant emergence (%) at 30 days after planting by counting of total number of tubers germinated per plot, incidence of major viral diseases were recorded time to time as per their appearance. At the time of harvesting of the crop tuber rottage (kg) per plot was recorded. Total tuber yield (kg/plot) with marketable tuber yield consisting big-medium tubers & tuber dry matter (%) were estimated within a week after harvesting in both 75 & 90 duration crops.

Formulas:

1.	Plant emergence (%)	=	No. of germinated plants per plot / Total no. of plants per plot	x	100
2.	Total tuber yield (t/ha)	=	Total wt. (kg) of all sized tubers per plot / Plot size (m^2)	x	10
3.	Marketable tuber yield (t/ha)	=	Total wt. (kg) of large to medium sized tubers per plot / Plot size (m^2)	x	10
4.	Tuber dry matter (%)	=	Wt. of sliced potatoes after 72 hrs oven dried followed by shade drying / Wt. of fresh harvest potatoes	x	100

To determine the marketable yield, very small tubers were sorted out from the total tuber yield. The marketable tuber yield consists of Big (≥80g) medium (79-50g) and small (49-25g) tubers.

4. RESULTS AND DISCUSSION

4.1 Plant Emergence

Data were recorded for plant emergence, 30 days after planting (Table 1). The plant emergence ranged from 98.61% (PS/16-17) to 84.45% (K. Lalit) in 75 days crop. In the experiment planted for evaluation in 90 days duration, the range was 97.23% (K. Keshar) to 90.00% (K. Manik). The results are given in Table 1 and Fig 1.

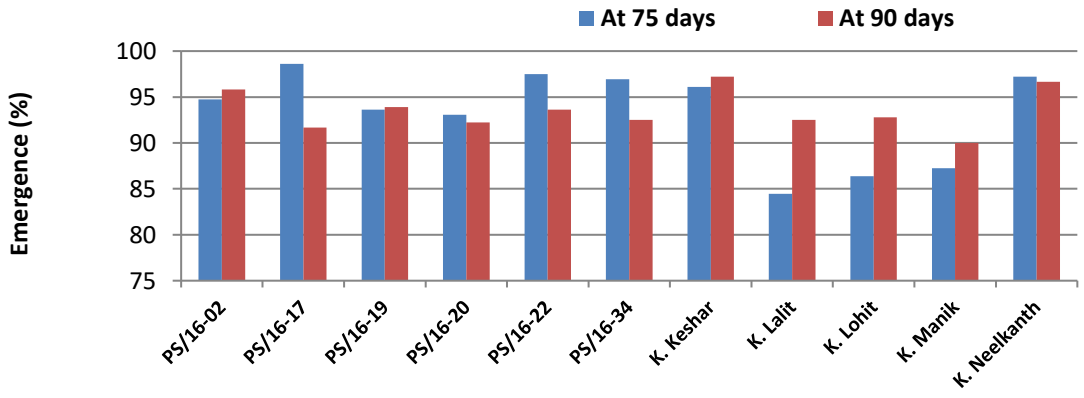

Fig. 1. Plant emergence (%) of advance clones/ varieties (pooled data 2021-22 & 2022-23)

Table 1. Plant emergence (%) of advance clones/ varieties (pooled data 2021-22 & 2022-23)

Advance clones /Varieties	Plant Emergence (%)	
	At 75 days	At 90 days
PS/16-02	94.73	95.83
PS/16-17	98.61	91.67
PS/16-19	93.61	93.89
PS/16-20	93.06	92.22
PS/16-22	97.50	93.62
PS/16-34	96.95	92.50
K. Kesar	96.11	97.23
K. Lalit	84.45	92.50
K. Lohit	86.39	92.78
K. Manik	87.23	90.00
K. Neelkanth	97.22	96.67
CD (0.05)	4.40	4.28
CV (%)	2.74	2.66

4.2 Total Tuber Yield

The total tuber yield was recorded maximum in PS/16-02 (27.62 t/ha) followed by K.Kesar (27.35 t/ha) in 75 days crop duration. In the 90 days crop experiment the total tuber yield was highest in K.Lohit (35.14 t/ha) followed by at par yield of PS/16-02 (32.14 t/ha) (Table 2 and Fig 2)

Table 2. Total tuber yield (t/ha) of advance clones/ varieties (pooled data 2021-22 & 2022-23)

Advance clones /Varieties	Total tuber Yield (t/ha)	
	At 75 days	At 90 days
PS/16-02	27.62	32.14
PS/16-17	23.44	27.10
PS/16-19	21.45	28.88
PS/16-20	21.19	19.63
PS/16-22	19.29	23.53
PS/16-34	22.41	27.67
K. Kesar	27.35	27.72
K. Lalit	24.61	28.15
K. Lohit	26.23	35.14
K. Manik	21.92	16.87
K. Neelkanth	26.25	29.03
CD (0.05)	3.82	5.68
CV (%)	9.52	12.59

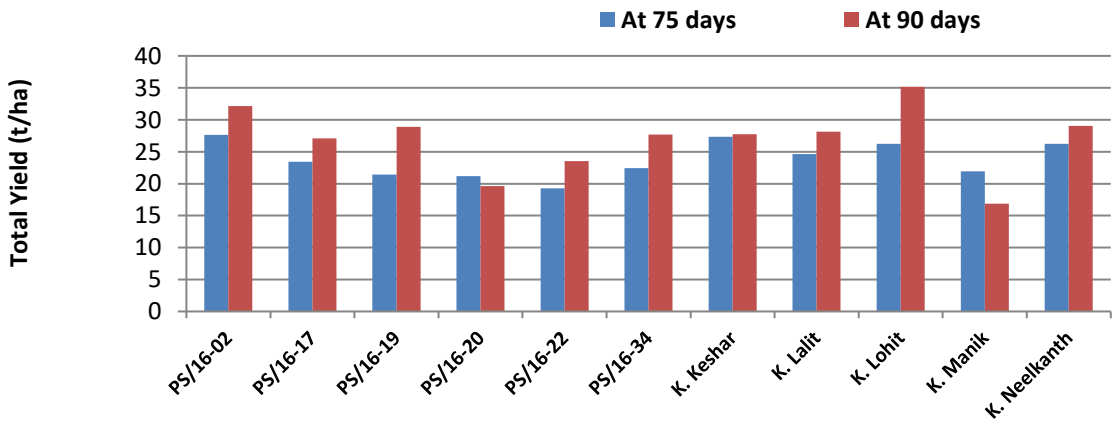

Fig. 2. Total tuber yield (t/ha) of advance clones/ varieties (pooled data 2021-22 & 2022-23)

4.3 Marketable Tuber Yield

The marketable tuber yield was recorded after subtraction of weight of very small tubers from the total tuber yield. In 75 days duration crop marketable tuber yield was maximum in PS/16-02 (26.29 t/ha) significantly superior over planted control varieties. In the 90 days crop highest marketable tuber yield was recorded in PS/16-02 (31.16 t/ha) followed by PS/16-19 (27.41 t/ha), PS/16-34 (26.41 t/ha), PS/16-17 (25.81 t/ha) & PS/16-22 (22.61 t/ha), significantly at par with the most of the control varieties (Table 3 and Fig 3).

4.4 Dry Matter

The dry matter content plays very important role in selection of clones. The range varies from 18.92% (PS/16-19) to 15.25% (K. Lohit) in 75 days duration crop. Whereas, in 90 days duration crop it ranged from 20.42 (PS/16-17) to 17.17% (PS/16-20). The dry matter performance of PS/16-17 was at par with PS/16-02 and these were significantly superior over the planted control varieties (Table 4 and Fig 4).

Table 3. Marketable tuber yield(t/ha) of advance clones/varieties (pooled data 2021-22&2022-23)

Advance clones /Varieties	Mkt. Yield (t/ha))	
	At 75 days	At 90 days
PS/16-02	26.29	30.16
PS/16-17	22.45	25.81
PS/16-19	20.30	27.41
PS/16-20	19.69	18.62
PS/16-22	18.48	22.61
PS/16-34	21.59	26.97
K. Kesar	26.21	26.28
K. Lalit	23.17	26.86
K. Lohit	24.88	33.78
K. Manik	21.19	16.04
K. Neelkanth	24.98	27.17
CD (0.05)	3.62	5.29
CV (%)	9.53	12.31

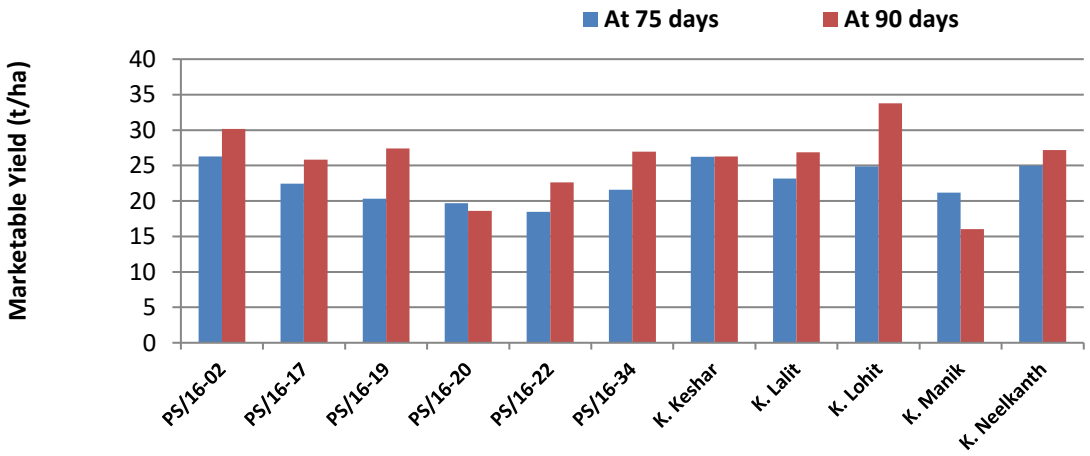

Fig. 3. Marketable tuber yield of advance clones (pooled data 2021-22 & 2022-23)

Table 4. Dry matter (%) of advance clones/ varieties (pooled data 2021-22 & 2022-23)

Advance clones /Varieties	Dry Matter (%)	
	At 75 days	At 90 days
PS/16-02	16.84	20.17
PS/16-17	17.84	20.42
PS/16-19	18.92	19.00
PS/16-20	16.00	17.17
PS/16-22	17.48	18.59
PS/16-34	18.67	19.08
K. Kesar	17.33	18.34
K. Lalit	18.42	19.92
K. Lohit	15.25	17.25
K. Manik	16.92	18.33
K. Neelkanth	16.42	18.17
CD (0.05)	0.88	1.01
CV (%)	3.02	3.22

Table 5. Nutritional components in advance clones/varieties (Pooled data 2021-22 & 2022-23)

Advance Clone/ varieties	Zn (ppm)	Fe (ppm)	Carotenoid (µg/100 gram fresh weight)	Anthocyanin (mg/100 gram fresh weight)	Vitamin C (mg/100 gram fresh weight)
PS/16-02	28.71	42.57	67.10	29.38	52.67
PS/16-17	24.41	48.40	73.85	7.79	50.65
PS/16-19	25.29	49.51	67.50	11.48	43.76
PS/16-22	27.28	50.87	109.50	22.07	42.35
PS/16-34	27.65	49.13	73.70	5.75	31.64
K.Kesar	31.70	41.88	150.80	0.46	39.71
K.Lalit	27.48	34.85	136.90	0.94	24.12
K.Lohit	26.15	41.40	124.00	0.84	28.89
K.Manik	26.55	44.79	79.05	0.93	31.54
K.Neelkanth	25.25	38.64	85.30	1.00	30.81

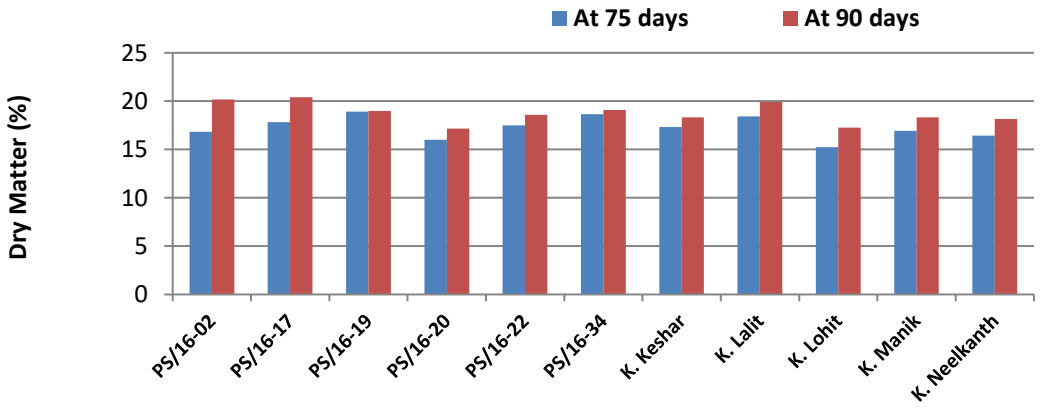

Fig. 4. Dry matter (%) of advance clones/ varieties (pooled data 2021-22 & 2022-23)

5. CONCLUSION

Medium maturing red and purple skinned advanced clones PS/16-02 and PS/16-17 were suitable for table potato with attractive, red & purple colour, with purple flesh and light red flesh colour respectively. The yield performance of PS/16-02 (27.62 t/ha) superior over best control K.Kesar (27.35 t/ha) during 75 days duration crop and at par (32.14 t/ha) with Kufri Lohit

(35.14 t/ha) during 90 days duration planted crop. The advance clone PS/16-17 was superior in dry matter (20.42 %), iron (48.40 ppm) and vitamin C (50.65 mg/100g fresh weight) over control varieties The tubers were round in shape with shallow eyes in the tubers. The organoleptic qualities of these clones were mealy texture; pleasant flavour (PS/16-02 and PS/16-17) and the colour retention of these clones were excellent after boiling of the tubers. The average cooking time of these clones were 15-18 minutes. High Anthocyanin colouration (PS/16-02) will promote the acceptance of these clones among the consumers.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that no generative AI technologies such as large language models (chat, GPT, COPILOT etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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