Evaluation of red skinned advance potato (*Solanum tuberosum* L.) clones for tuber yield and yield parameters in Eastern Indo-Gangetic plains of India

ABSTRACT

Potato is a very important tuber crop used as staple vegetable in almost every household. India ranks second in potato production after China. The production of potato increased significantly during last six decades. There is remarkable increase in potato yield and production during last decade 1.10 and 5.98% per annum respectively at national level (Rani & Prasoon, 2013). The important yield and yield attributing traits are plant emergence (%), number of tubers/plots, tuber yield/plot and tuber dry matter (%). The present experiment was conducted at experimental field of ICAR- Central Potato Research Institute Regional Station Patna, Bihar. In this experiment data were recorded for plant emergence (%), seed wt (t/ha), foliage senescence (%),total and marketable tuber yield (t/ha), dry matter content in percentage (haulm and tuber), late blight (%), leafspot disease (%) during 75- and 90-days crop. The trial wasconducted in randomized block design with three replications to evaluate nine advance clones namely MS/11-664, MS/13-527, MS/14-1381, MSP/16-307, MSP/16-375, PS/11-47, PS/13-45, CP-4409 and Memphis along with sevenpotato varieties Kufri Khyati, Kufri Lalima, Kufri Lalit, Kufri Manik, Kufri Mohan, Kufri Pukhraj and K Neelkanth as controls during 2020-21 & 2021-22.The advance clones PS/13-45 (36.97t/ha), PS/11-47 (35.87t/ha), MS/11-664 (35.39t/ha) were good candidates for future new potato varieties in Eastern Indo Gangetic plains of India.

Keywords: Potato, advance clones, tuber yield, dry matter content, Potato varieties.

INTRODUCTION

Potato (*Solanum tuberosum L.*) is an important tuberous vegetable crop ranked fourth worldwide after maize, wheat and rice. The global annual production is about 371.14 million metric tonnes with an area of about 17.3 million hectares of land. The average productivity is about 20.9 tons/ha at world level (FAOSTAT 2019).It is grown for family food security and income generation. It iscultivated all over India, during rabi season in northern states and during kharif season in most of the southern states.India ranked second after China, shares 13.08% (48.56 million tonnes) of world production (FAOSTAT 2022).The main challenges causing this low potato productivity include small and fragmented land holdings, poor linkage of potato producers and markets, poor financial condition of farmers, post-harvest losses and limited supply of quality seeds, pest and disease incidence, limited numberof improved, high yielding potato varieties(Muhinguza*et.al.* 2012; Rukundo*et.al.*2019). The potato varieties Kufri Jyoti, Kufri Pukhraj, Kufri Arun,and Kufri Sindhuriwere developed based on that time; nowadays nutritionally superior potato varieties are in demand. As food fortification is the prime objective of the government andpotato processing industriesrequire the potato varieties with high dry matter content, low reducing sugar content, good tuber colour &shape and shallow eyes (USAID, 2016). Potato tubers provide raw materials to industries producing chips, crisps, starch, spirits and alcohol (Das *et al*. 2021). The enhancement inpotato production will depend on the availability of new adopted varieties resistant or tolerance to majorviral diseases with high nutritional status. As red skinned are preferred over white skinned varieties in eastern Indo-Gangetic plains, these advance potato clones are able to meet the needs of the region. The present study was aimed at identifying the potential of advance clones for their yield performance and adoptability under Eastern Indo-Gangetic plains of India.

Picture 1 : Planting of initial clona generation

Picture 2: Crop planted on ridges

Picture 3 :Selection of the clones

Potatoes can provide more nutritious food per unit of land and time, even when planted under unfavourable conditions, compared to other staple crops like maize, wheat, and rice.". It is highly efficient crop, converts natural resources into a high-quality food, with high yield and with good response to agriculture inputs (Horton 1987). Potatoes are very rich in various nutrients such as carbohydrate, amino acid, vitamins, minerals, anti- oxidant, dietary fibers, and protein (Beals 2019; Burgos, *et al.*2020). It is consumed in different ways such as boiled, roasted, French fries, chips and ready to eat foods. It is important source of food for many low-income people in both urban and rural areas (Kibar 2012). It is fat free vegetable with no cholesterol (Bartova*et al.* 2015; Kowalczewski *et al.* 2019). Potato bears high value in terms of production favoursadoption by farmers and dissemination by governmental agriculture agencies. In eastern Indo-Gangetic plains, potato is an important crop grown for family food security and income generation.

MATERIALS AND METHODS

Potato is a cool season crop. It performs best in cool reasons with sufficient moisture and fertile soil well prepared field is required for conducting a successful experiment. It performs well if soil temperature range is between 17-19^{0}C because this temperature favours the tuber development. Potato can be grown on wide range of soils from sandy loam, silt loam and clayey soils. Well drained field is required for conducting the experiment as well for growing of the crop. The soil pH range from 5.0-6.5 (Chhidda Singh, 2001).

1. **Planting materials**
   The material in this study were 9 advance clones of potato namely MS/11-664, MS/13-527, MS/14-1381, MSP/16-307, MSP/16-375, PS/11-47, PS/13-45, CP-4409 and Memphis along and seven control potato varieties Kufri Khyati, Kufri Lalima, Kufri Lalit, Kufri Manik, Kufri Mohan, Kufri Pukhraj and K Neelkanth.

2. **Location of Experiment**
   The experiment was conducted at experimental field of ICAR-CRPI RS Patna during the year 2020-21 & 2021-22. The advance clones were planted as per the approved technical programme of All India Coordinated Research Project on Potato from November 10-15, 2020-21 & November 8-12, 2021-22 during *Rabi*season. The cropping season starts from November and ends during last week of February with the harvesting of the crop.

3. **Experimental Design**
   The design of the experiment was completely randomizedblock design with three replications in two sets i.e. experiment harvested with 75 days after planting and 90 days after planting. All advance clones along with check varieties were planted in 5 rows of 12 tubers (3.0 m x 2.4 m) with the area 7.8 m^2.

4. **Field preparation**
   A well-prepared field is required for good stand of the potato crop. Field is prepared by deep ploughing (20-25 cm deep) with soil turning plough, after that 2-3 cross harrowing followed by 2-3 shallow ploughed followed by leveling is required for good tuberization of the potato crop. Planking also plays an important role for leveling of the field and retention of the available moisture in the field, which plays important role at the time of sowing (Chhidda Singh, 2001).

5. **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 20 cm and row to row distance was 60 cm. After planting of the crop, light irrigation was given in the field provided in order to get even germination of the tubers.

6. **Manure and fertilizers**
   Potato crop is a heavy feeder crop, it requires high doses of fertilizers i.e. 180: 60:80 (N:P:K).Along with these fertilizers 22-25 tonnes/ha well decomposed farmyard manure was applied for getting better tuber yield. At the time of land preparation half doses of Nitrogen with full dose of Potassium & Phosphorous were applied as basal. A good potato crop yields about 35 to 40 tonnes tubers per hectare (Chhidda Singh, 2001).

7. **Method of planting**
   The ridges were made after land preparation with the help of tractor driven ridge-maker. Bed cuttingas per layout of the experiment was done (3mx 60cmx 5 lines). The planting of potato tubers was done with the help of *khurpi* at the depth of 7-8 cm and after that tubers were covered with soil. Light irrigation just after planting was given to get the even germination of experimental material.

8. **Inter culture operations**
   After planting of the crop, weedicide Oxflurofen 23.5%SC(500 ml/ha) was sprayed at pre-emergence stage.All inter culture operations like weeding, earthing up etc. were done manually as per requirementof the crop. After hoeing remaining half dose of Nitrogen in the form of urea was applied in side of the furrows and then earthing up was done in order to get better tuberization in the crop. In potato crop 4-5 irrigationsat an interval of 15 days were given, the interval may vary as per requirement. Late blight of potato is very serious disease in this crop and the control can be done by one prophylactic spray ofMancozeb 75WP followed by 2 sprays of Cymoxanil 8% + Mancozeb 64% WP at an interval of 15 days. For control of as aphids and pest such as potato leaf cutters, cutworms etcImidacloprid 17.8% SL was sprayed in 45 days crop.

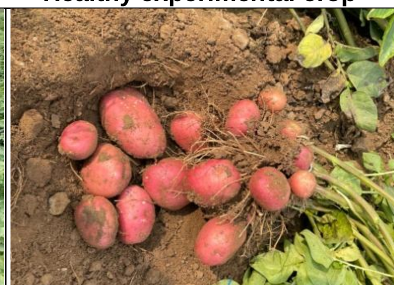
Photos1: Important agronomical practices in potato cop

Planting of potato on ridges

Healthy experimental crop

Earthing up in the crop

Recording of observations



Selected red-skinned potato clone

Harvesting of tubers

DATA COLLECTION AND RECORDING OF OBSERVATIONS

The important observations were recorded for plant emergence (%), foliage maturity (%), total tuber yield (t/ha), marketable tuber yield (t/ha), dry matter (%) and disease reaction (%) 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. 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. Foliage senescence data was recorded from 60 days after planting to 90 days after planting at interval of 10 days. At the time of harvesting of the crop tuber rottage(kg) per plot was recorded.Total & marketable tuber yield (kg/plot) with marketable tuber yield consisting big-medium tubershaulms weight (%) & tuber dry matter (%) were estimated within a week after harvesting in both 75 & 90 duration crops.

Formulas:

1. Plant emergence (%) $$= \frac{\text{No. of germinated plants per plot}}{\text{Total no. of plants per plot}} \times 100$$

2. Seed wt. (t/ha) $$= \frac{\text{Wt. of seed tubers per plot (kg)}}{\text{Plot size (m}^2\text{)}} \times \begin{matrix} 10000 \\ 1000 \end{matrix}$$

3. Foliage senescence (%) $$= \frac{\text{No. of plants with 75\% foliage maturity per plot}}{\text{Total no. of plants per plot}} \times 100$$

4. Total tuber yield (t/ha) $$= \frac{\text{Total wt. (kg) of all sized tubers per plot}}{\text{Plot size (m}^2\text{)}} \times \frac{10000}{1000}$$

5. Marketable tuber yield (t/ha) $$= \frac{\text{Total wt. (kg) of large to medium sized tubers per plot}}{\text{Plot size (m}^2\text{)}} \times \frac{10000}{1000}$$

6. Tuber dry matter (%) $$= \frac{\text{Wt. of sliced potatoes after 72 hrsoven drying}}{\text{Wt. of fresh harvest potatoes}} \times 100$$

7. Haulm dry wt. (%) $$= \frac{\text{Wt. of haulms per plot after dehaulming}}{\text{Wt. of dried haulms per plot at harvesting}} \times 100$$

Foliage maturity was recorded at 60 days after planting and continues up to 90 days after planting. The data on this parameter was recorded atan interval of 10 days. 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.

Table 1: Plant emergence (%), seed wt. (t/ha), total & marketable tuber yield (t/ha), tuber dry matter (%) & haulm dry wt. (%) in 75 days crop (pooled data 2020-21 & 2021-22)

Hybrid/ Variety	Emergence (%)	Seed wt.(t/ha)	Foliage senescence (%)	Yield (t/ha)		Dry matter (%)
				Total	Mkt.	Tuber
CP-4409	97.78	3.98	30.00	32.45	22.09	15.40
Memphis	95.55	4.03	51.67	27.39	21.24	11.40
MS/11-664	95.56	4.07	58.33	30.47	22.55	14.95
MS/13-527	96.67	4.03	16.67	30.20	23.26	14.25
MS/14-1381	98.33	4.12	20.22	24.49	21.92	13.50
MSP/16-307	78.89	3.83	25.33	21.92	18.55	14.83
MSP/16-375	73.89	3.93	20.67	16.55	14.53	11.67
PS/11-47	94.45	4.00	16.67	34.78	29.88	16.07
PS/13-45	97.22	3.68	50.33	36.19	33.02	15.67
K Khyati	96.95	3.99	31.67	35.00	28.28	14.59
K Lalima	96.67	4.12	41.67	26.00	25.49	16.90
K Lalit	97.23	3.99	51.67	27.20	21.28	15.79
K Manik	96.00	3.96	35.00	27.25	25.53	13.73
K Mohan	96.95	4.00	31.67	27.33	21.43	13.00
K Pukhraj	97.78	4.14	51.67	32.99	27.62	15.24
K Neelkanth	96.11	3.87	35.33	25.60	21.45	17.17
SEd	1.78	0.16	2.34	1.68	1.29	0.48
CD (0.05)	4.28	NS	4.92	3.49	2.68	1.00
CV (%)	2.30	4.79	7.58	7.03	6.58	3.96

Table 2: Plant emergence (%), seed wt. (t/ha), total & marketable tuber yield (t/ha), tuber dry matter (%) & haulm dry wt. (%) in 90 days crop(pooled data 2020-21 & 2021-22)

Hybrid/ Variety	Emergence (%)	Seed wt.(t/ha)	Foliage senescence (%)	Yield (t/ha)		Dry matter (%)
				Total	Mkt.	Tuber
CP-4409	96.67	4.13	88.33	34.91	23.86	16.93
Memphis	91.67	3.99	86.67	28.10	25.31	16.77
MS/11-664	96.39	4.00	90.00	35.39	27.75	18.04
MS/13-527	95.06	4.05	90.00	31.21	24.20	17.10
MS/14-1381	98.33	4.29	80.67	34.17	30.78	18.50
MSP/16-307	77.22	4.08	83.33	26.72	20.43	18.33
MSP/16-375	71.11	4.22	88.33	18.73	17.28	15.17
PS/11-47	97.22	4.05	83.33	35.87	31.10	19.69
PS/13-45	95.00	4.12	90.67	36.97	33.47	19.17
K Khyati	97.22	3.81	83.33	35.15	30.06	15.94
K Lalima	96.95	4.05	85.00	28.76	28.90	18.84
K Lalit	97.78	4.02	93.33	32.77	27.33	18.04
K Manik	94.84	3.80	87.33	30.67	27.46	16.60
K Mohan	95.28	3.99	93.33	40.90	34.02	16.47
K Pukhraj	97.78	4.03	88.33	32.86	29.70	17.37
K Neelkanth	96.67	4.21	90.00	29.54	24.20	20.67
SEd	49.78	0.18	2.77	2.08	1.20	0.78
CD (0.05)	5.95	-	5.82	4.35	2.50	1.30
CV (%)	3.21	5.38	3.86	7.97	5.44	5.50

DATA INTERPRETATION AND ANALYSIS

Data recorded and collected from the experiment on various aspects such as plant emergence, foliage maturity, total tuber yield, marketable tuber yield, tuber dry matter, haulm dry matter, disease reaction etc. The recorded data were analyzed by using OPSTAT (HAU, Hissar, 2022).

RESULTS and DISCUSSION

The performance of studied advance clones are shown in the table 3 below –

Table 3: Range of various parameters

Parameters	Range	
	75 DAP	90 DAP
Emergence (%)	73.89 - 98.33 Highest - MS/14-1381 (98.33) Lowest - MSP/16-375 (73.89)	71.11 - 98.33 Highest - MS/14-1381 (98.33) Lowest - MSP/16-375 (71.11)
Seed wt.(t/ha)	3.68 - 4.14 Highest - MS/14-1381 (4.12) Lowest - PS/13-45 (3.68)	3.8 - 4.29 Highest - MS/14-1381 (4.29) Lowest - Memphis (3.99)
Foliage senescence (%)	16.67 - 58.33 Highest - MS/11-664 (58.33) Lowest - PS/11-47 (16.67)	80.67 - 93.33 Highest - PS/13-45 (90.67) Lowest - MS/14-1381 (80.67)
Total tuber yield (t/ha)	16.55 - 36.19 Highest - PS/13-45 (36.19) Lowest - MSP/16-375 (16.55)	18.73 - 40.9 Highest - PS/13-45 (36.97) Lowest - MSP/16-375 (18.73)
Market tuber yield (t/ha)	14.53 - 33.02 Highest - PS/13-45 (33.02) Lowest - MSP/16-375 (14.53)	17.28 - 34.02 Highest - PS/13-45 (33.47) Lowest - MSP/16-375 (17.28)
Tuber dry matter (%)	11.4 - 17.17 Highest - PS/11-47 (16.07) Lowest - Memphis (11.4)	15.17 - 20.67 Highest - PS/11-47 (19.69) Lowest - MSP/16-375 (15.17)
Haulm dry matter (%)	9.35 - 24.99 Highest - MSP/16-307 (21.54) Lowest - Memphis (9.35)	8.02 - 11.23 Highest - MS/11-664 (11.23) Lowest - Memphis (8.02)

- DAP- Days after planting

1. **Plant emergence**

The plant emergence ranged from 98.33 to 73.89. Highest emergence was observed in the advance cloneMS/14-1381 (98.33) followed by CP-4409 (97.78). The plant emergence is positively correlated with the yield performance of the advance clone. (table 1, 2 and Fig 1)

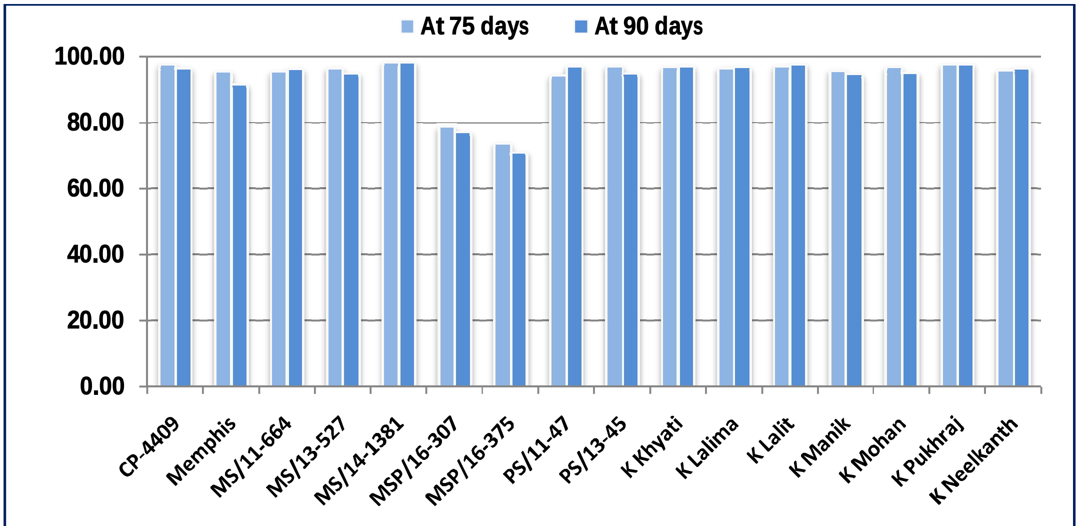


Fig. 1 - Percent Emergence at 75 & 90 days

2. Yield performance

Among the tested advanced potato clones, the highest yield was recorded in PS/13-45 (36.19 t/ha) and it is significantly superior to the planted control varieties followed by the advance clone PS/11-47 (34.78 t/ha) which was at par with controls. Also both these advance clones showed significantly superior marketable tuber yield over controls(table 1, 2 and Fig 2,3)

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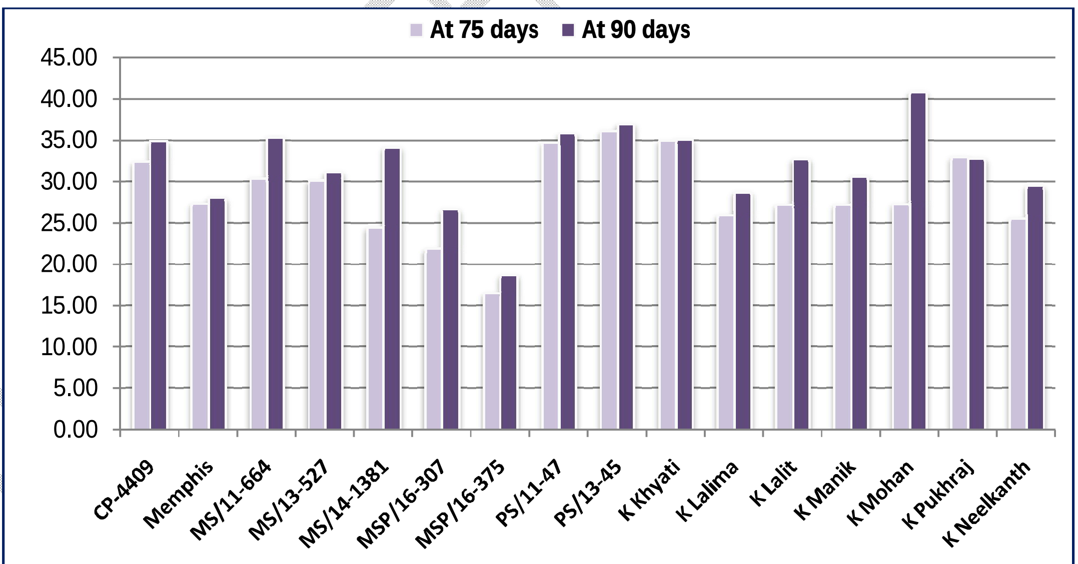

Fig. 2 - Total Tuber Yield (t/ha)

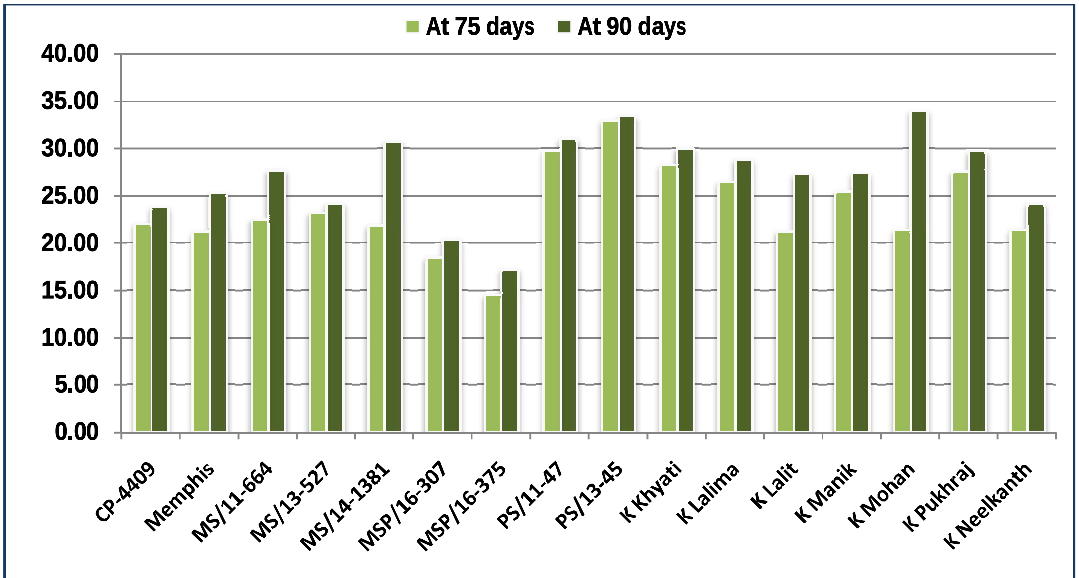

Fig. 3 - Marketable Tuber Yield (t/ha)

3. **Dry matter content**
The highest dry matter was observed in the advance clone PS/11-47 (16.07 %), followed by the clonePS/13-45 (15.67 %) which areat par to the control varieties. The drymatter is positively correlated with the processing qualities of the tubers. High dry matter content isdesirable for the processing industries associated in making chips, French fries etc.(table 1, 2 and Fig 4)

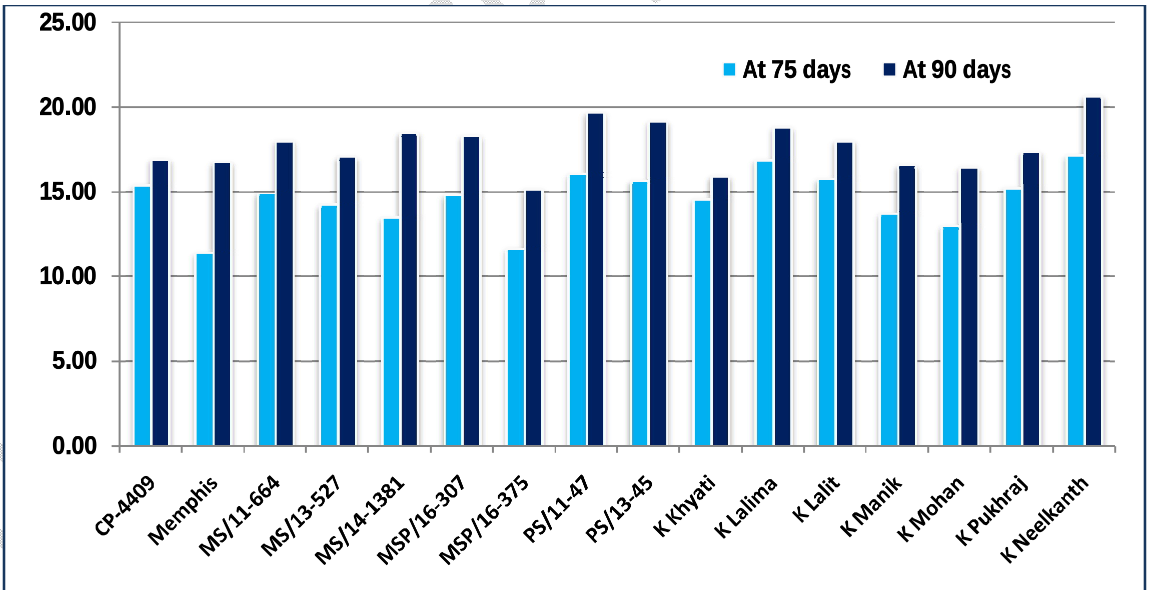

Fig. 4 - Dry Matter (%) during 75 & 90 days crop

Yield is very important parameter in selection and release of the potato varieties. The genetic makeup of the potato varieties expresses well under favorableenvironmental factors such as fertility of the soil, surrounding temperature, water availability, pH of the soil, genotype and environmental interaction affect the crop yield in different ways (Patel *et al.*, 2008). This study was aimed to determine the overall performance of nine advance potato clones along with seven controls varieties. According to Tessema*et al.*(2020) the genotype and environment interaction has considerable influence on the quality and quantity of tubers yield. Rukundo *et al.* 2019, reported that the significant difference in total yield among potato genotypes is attributed to the intrinsic yield potential of genotypes, growing environment, and the interaction of genotype x environment. Superior potato genotypes have capability to utilize available soil nutrients; therefore, in the variety selection processthe adaptability of tested genotypes has to be determined in order to recommend a variety to farmers with specific or broad adaptability.

CONCLUSION

Potato genotypes have significant difference with respect to the tuber yield and number of tubers per plant across of all locations. According to Patel *et al.* (2008) and Subarta and Upadhya (1997), the variations among the genotypes for number of tubers per plant and tuber yield are associated with the inherent potential of variety which is highly influenced by growing conditions and interaction of variety by environment. This was also highlighted by Firman and Daniels (2011) reporting that a high number of tubers per plant are influenced by varietal characteristics, adaptability andimpact of the growth attributes, best clones should have a high yield with a high number of marketable tubers. The potato tubers yield ranging between 21.7 and 40.3 tons/ha was reported by Mulema*et al.* (2008). In the present study the advance clones PS/13-45 (36.97t/ha), PS/11-47 (35.87t/ha), MS/11-664 (35.39t/ha) are good candidates for future new potato varieties in Eastern Indo Gangetic plains of India.

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.

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