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Evaluation of red-skinned potato hybrids/varieties in north central plains of India

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Abstract
The present experiment was laid out in the field of the experimental area of ICAR-CPRI-RS, Maharajpura, Gwalior (M.P.) during the *rabi Season of* two consecutive years *i.e* 2020-2021 and 2021-2022. The experimental material for this study comprised 5 Hybrids and 6 controls as treatment *viz*., MS/11-664, CP-4409, MS/14-505, MS/14-1381, MS/13-527, Kufri Khyati, Kufri Pukhraj, Kufri Mohan, Kufri Lalit, Kufri Sindhuri. Kufri Neelkanth. The experiment was laid out in a randomized block design with three replications of each treatment. Nitrogen, phosphorus, and potassium were applied, through ammonium sulfate & urea, single super phosphate, and muriate of potash respectively. A uniform dose of 180 kg N ha^{-1}, 80 kg P $ha^{-1,}$ and 120 kg K ha^{-1} was applied to all the plots. Haulm uprooting of the potato crop was done at 60 DAP, 75 DAP, and at senescence for the evaluation of red-skinned potatoes as per Days of emergence, Final emergence % at 30DAP, Number of stems per plant, Plant height(cm), Diameter of the stem(cm), and yield attributing parameters. At 75DAP hybrid, MS/14-505 recorded (43.11t/ha.) significantly higher tuber yield. At 90DAP hybrid MS/14-505 recorded a significantly higher tuber yield (52.92 t/ha.). At senescence, Hybrid MS/14-505 recorded a significantly higher tuber yield (73.06 t/ha.). It is also concluded that among controls at 75 DAP Kufri Lalit recorded the highest tuber yield 40.36t/ha while at 90DAP and senescence Kufri Khyati recorded the highest tuber yield 50.15t/ha. and 64.89t/ha., respectively ratio among controls at 90DAP and senescence, respectively. Hence it is concluded that Hybrid MS/14-505 was spotted best among different hybrids and controls followed by hybrid MS/14-1381 for the cultivation of red-skinned potatoes in the north central plains of India.

Keywords: Potato, colour, kufri neelkanth, significant, solanum

Introduction
Potato considered as 'King of Vegetables' or Wholesome miracle food' is a Dicot, the thermosensitive plant has a place with the genus *Solanum* that involves around 2000species of which just <10 percent is tuber bearing (Vos, 1999) [25]. *Solanum tuberosum* L., the autotetraploid potato genotypes that are developed today is a member of the Solanaceae family with a genomic constitution of 2n=4x=48. Potato is a short-duration perennial herb, developed as an annual which produces enlarged underground stems(tubers) known as 'aloo' countrywide. Globally, potato significantly ranks fourth in importance among food crops after rice, wheat, and maize and is featured as the most important commercial crop that contribute to food security on a global scale due to quick and better nutritious produce per unit area and fits well into different cropping pattern with economic benefits. In India, Potato is cultivated in the 2161('000 Ha) area with an average production of 53027 ('000MT) and productivity of about 24.5 MT/ha. (Anon, 2018) [1]. The west-central and eastern plains account for nearly 75% of the country's potato production. Potato is a long-day plant but is cultivated as a short-day plant in India during winter. The young plants develop best at a temperature of 18°C. Tuber production is most extreme at 20°C and diminishes with the temperature increase and is halted at around 30°C. Potatoes' ideal development is seen when days are bright and evenings are cool.

Potato tuber color is a significant factor that impacts consumers' inclinations. Generally, white or yellow skin potatoes are in demand over red skin potatoes. Red-eyed potatoes have been preferred in eastern India and a few areas of eastern UP and Bihar because of the high nutritive quality they are currently being liked in certain pockets of North-Western and West-central parts of India. Growing awareness for supplement-rich food can make a specialty on the lookout for nutritious potatoes. Red skin potatoes are normally cooked with meat in Jammu and Kashmir. Such colored potatoes are liked by individuals to add tone and taste to the feast.

North-central plains comprise western-central Uttar Pradesh and Northwestern Madhya Pradesh where potatoes are grown in a 90-100 days span during winter under milder temperatures and short days. In North-Central India areas of Agra and Gwalior are having high yield potential due to mild winters but are constrained by a high-water deficit (Govindakrishna *et. al.*, 2015) [6]. The optimum planting time for potatoes in the Indo-Gangetic plains is in the middle of October and harvesting is in February/March (Kumar *et. al.*, 2007) [7]. A minimum of 70-90 days of the favorable cool season is required to obtain an economical yield.

Materials & Methods

The present experiment was laid out in the field of the experimental area of ICAR-CPRI-RS, Maharajpura, Gwalior (M.P.) during the *rabi Season of* two consecutive years *i.e* 2020-2021 and 2021-2022. The soil of the experimental field was silt clay loam to silt loam having good drainage. The experimental material for this study comprised 5 Hybrids and 6 controls as treatment *viz*., MS/11-664, CP-4409, MS/14-505, MS/14-1381, MS/13-527, Kufri Khyati, Kufri Pukhraj, Kufri Mohan, Kufri Lalit, Kufri Sindhuri. Kufri Neelkanth. The experiment was laid out in a randomized block design with three replications of each treatment. The experimental field was prepared to a fine tilth by two deep plowing followed by two cross harrowing. The field was divided into 33 plots having irrigation channels and paths. Ridges were prepared 60 cm apart in each plot. The height of the ridges was kept at 20 cm and there were 5 ridges in each plot. Healthy, uniform, medium-sized tubers (40-50 g) at the rate of 35q ha^{-1} were used. Shallow furrows were opened 6 cm apart with the help of a pick axe manually and tubers were dibbled at a spacing of 60 cm row to row and 20 cm plant to plant. Two weeks after planting, gap filling was done. The Standard recommended package of practices was followed to raise a healthy crop. Nitrogen, phosphorus, and potassium were applied, through ammonium sulfate & urea, single super phosphate, and muriate of potash respectively. A uniform dose of 180 kg N ha^{-1}, 80 kg P $ha^{-1,}$ and 120 kg K ha^{-1} was applied to all the plots. Haulm uprooting of the potato crop was done at 60 DAP, 75 DAP, and at senescence (70% foliage maturity DAP) and tuber digging was done after 10-12 days after haulm uprooting by using a spade, manually. Various morphological and yield parameters were studied during the experiment. The data based on the mean of individual plants selected for observation were statistically analyzed to find out the overall total variability present in the material under study for each character and for all the populations. The first and foremost step is to carry out an analysis of variance to test the significance of differences among the populations. The analysis of variance was carried out as per methods suggested by Panse and Sukhatme (1967) [11].

Result and Discussion

The data obtained from the first year (2020-21), second year (2021-2022) and pooled with 5 hybrids and 6control/checks as treatments are statistically analyzed for different parameters.

Days of emergence

The data in Table 1 for days of emergence was found significantly different among different hybrids and varieties. Hybrid CP-4409 recorded minimum days taken to emergence (10.50) was found at par with hybrid MS/14-505 (11.33) and control Kufri Khyati (11.17). Sadawarti *et. al.* (2014) [17] concluded that under the Gwalior region condition of central India, Kufri Sindhuri, Kufri Lauvkar, and Kufri Chandramukhi took 11 days to emerge which indicates significant differences in varieties for days to emerge. A similar variable trend followed in hybrids and control in the present study. Ebrahim *et. al.* (2018) [4] that the Local variety (Kellacho) took the longest time to emerge over the two improved varieties (Gudenie and Jalene).

Final emergence % at 30DAP

The result revealed in Table 1 that there was no significant difference found among the hybrids and controls regarding final emergence % at 30DAP and ranged between 91.78 to 96.06% in the present study which shows that the planting of well-sprouted tubers resulted in better germination in all hybrids and controls. Present results are by Verma *et. al.* (2013) [24], Deshmukh *et. al.* (2018) [2], Preetham *et. al.* (2018) [13], Sati *et. al.* (2018) [20], and Sadawarti *et. al.* (2014) [17] who also noted non-significant differences in the final emergence percentage among varieties.

Number of stems per plant

The number of stems per plant at 45DAP recorded and presented in Table 1 shows that the maximum under control Kufri Sindhuri (6.67) which is found statistically at par with hybrid MS/13-527 (6), CP-4409 (5.67) along with control Kufri Mohan (5.17) which recorded significantly higher over other hybrids and controls. Such variations were reported by Mann *et. al.* (2017) and in conformity by Sadawarti *et. al.* (2019) [16] and Foroghian *et. al.* (2019) [5] where the significantly maximum stem number was in Kufri Surya (4.90) followed by Kufri Pushkar (3.70), Kufri Badshah (3.63) and Kufri Pukhraj (3.60). (Sadawarti *et. al.* 2014) [17].

Plant height(cm)

Plant height(cm) at 45DAP recorded and presented in Table 1 shows a significant difference among the hybrids and controls revealed maximum height in hybrid MS/14-505(56.68 cm) which is found statistically at par with hybrid MS/14-1381(55 cm) and control Kufri Sindhuri, Kufri Lalit whereas minimum plant height (cm) at 45DAP was recorded under control Kufri Mohan (48.71 cm). The present response was also supported by Eaton *et. al.* (2017) [3], who reported the varied plant height of different potato genotypes might be due to environmental effects and plant genetic makeup. The maximum plant height was recorded in Kufri Badshah (57.77 cm) followed by Kufri Sadabahar (40.19 cm) reported by Mann *et. al.* (2017). A similar trend was also reported by Khan *et. al.* (2019), Preetham *et. al.* (2018) [13], and Mehara *et. al.* (2018) [10].

Diameter of the stem(cm)

It is evident from the data that the diameter of the stem(cm) at 50DAP shows a significant difference among the treatments and ranges between 1.91cm to 2.16cm. The maximum diameter of the stem(cm) at 50DAP was recorded under hybrid MS/14-1381(2.16cm) which is found statistically at par with hybrid MS/14-505(2.15cm), MS/11-664(2.12cm), along with control Kufri Sindhuri (2.11cm), Kufri Khyati (2.09cm), Kufri Mohan (2.07cm). Present findings confirmed with Raj *et. al.* (2016) [14] who reported that the maximum

stem diameter in Kufri Arun (4.09 cm) and minimum in Kufri Chipsona-4 (3.05 cm). Similar trends were also reported by Zheng Xu *et. al.* (2012) [26].

Yield attributing parameters

Total number of tubers (thousand/ ha.)

It is depicted in Table 2 that the total number of tubers/ha. at 75, 90 days after planting (DAP), and at senescence recorded shows variation in the number of total tubers/ha. At 75 days after planting recorded control Kufri Sindhuri (966.2 tubers/ha.) recorded significantly higher which was found statistically at par with hybrid MS/14-505, MS/14-1381, and MS/13-527 along with control Kufri Pukhraj and Kufri Neelkanth and Hybrid MS/11-664 recorded the lowest number of tubers/ha. (596.76tubers/ha.). At 90 days after planting recorded Hybrid MS/14-505 (947.22tubers/ha.) recorded significantly higher which was found statistically at par with hybrid MS/14-1381, and MS/13-527 along with control Kufri Khyati, Kufri Pukhraj, Kufri Mohan, Kufri Sindhuri and Kufri Neelkanth and Hybrid MS/11-664 recorded the lowest number of tubers/ha. (683.33 tubers/ha.). At senescence recorded Hybrid MS/14-505 (1208.33 tubers/ha.) recorded significantly higher which was found statistically at par with hybrid MS/14-1381, and MS/13-527 along with control Kufri Khyati, Kufri Pukhraj, Kufri Sindhuri, and Hybrid MS/11-664 recorded the lowest number of tubers/ha. (877.78 tubers/ha.). Current findings are in agreement with Singh and Lal (2015) [21] who got a 5.7% higher total tuber number per hectare as compared to lal gulab variety. Among varieties, Kufri sindhuri recorded a maximum no. of total tuber no. (670 thousand/ha) over the other three varieties (Sadawarti *et. al.*, 2018) [18]. Also supported by (Sadawarti *et. al.*, 2019) [16] who noted that the mean total tuber number found maximum in variety Kufri Sindhuri (648 thou. /ha) over Kufri Chandramukhi and Kufri Chipsona-1, when planted under west-central Indian condition for seed production. Similar variations among different genotypes were also recorded in current findings.

Total yield of tubers (t/ha.)

The total yield of tubers (t/ha.) depicted in Table 2 at 75, 90 days after planting (DAP) and at senescence recorded shows variation in the yield of total tubers. At 75 days after planting recorded Hybrid MS/14-505 (43.11t/ha.) recorded significantly higher which was found statistically at par with hybrid MS/14-1381 along with control Kufri Lalit and control Kufri Sindhuri recorded the lowest yield of tubers (t./ha.) (34.12 t./ha.). At 90 days after planting recorded Hybrid MS/14-505 (52.92 t/ha.) recorded significantly higher which was found statistically at par with hybrid MS/14-1381 along with control Kufri Mohan, Kufri Khyati, and Kufri Pukhraj and control Kufri Sindhuri recorded the lowest yield of tubers (t./ha.) (38.63 t/ha.). At senescence recorded Hybrid MS/14-505 (73.06 t/ha.) recorded significantly higher which was found statistically at par with hybrid MS/14-1381 and the lowest yield of tubers (t./ha.) recorded in control Kufri Lalit recorded (50.9 t/ha.). Lemma Tessema *et. al.* (2020) reported that Belete variety produced the maximum (32.8 t /ha) and farmers variety Nech Abeba (13.8 t ha-1) observed the lowest total tuber yield per hectare. Sadawarti *et. al.* (2014) [17] who noted that among varieties, for total tuber yield found significantly higher in K. Sindhuri (29.54 t/ha) over the other three varieties. Luthra *et. al.* (2017) concluded that MS/5-1543 (17.83, 27.58 and 34.17 t/ha) produced maximum yield at 60, 75 and 90 days and minimum yield recorded in Kufri Pukhraj (14.92, 24.26 and 29.90 t/ha). Out of 44 genotypes, J/93-86 (328.88 kg/plot), MS/95-1309 (328.05 kg/plot) and Kufri pukhraj (294.44 kg/plot) posseses higher mean total tuber yield as compared to other genotypes under Chattisgarh region (Rangare *et. al.*, 2017). Poudel et.al (2018) reported higher total tuber yield in genotype PRP 276264.1(40.14 t/ha) and CIP 393617.1(36.81 t/ha) and genotype CIP 395017.242(7.05 t/ha) found lowest under Eastern mid hills condition at Dhankuta. For total yield, three early maturing (J/9-141, J/7-15, J/7-37) hybrids found superior in pune region at 60- and 75-days crop (AICRP annual report, 2018-19). Current results were conformity with Singh and lal (2015) [21], Deshmukh *et. al.* (2018) [2], Sadawarti *et. al.* (2018) [18], Sadawarti *et. al.* (2019) [16], Eaton *et. al.* (2017) [3], Ebrahim *et. al.* (2018) [4] and Solomon *et. al.* (2019) [22]. The higher yield in the Kufri Khyati (28.22 t/ha), Kufri Ganga (28.69 t/ha), Kufri Pukhraj (28.28 t/ha) and hybrid P-27 (25.59 t/ha), P-36 (26.12 t/ha) and P-40 (26.31 t/ha) at 60 days and in Kufri Mohan (41.26 t/ha) Kufri Khyati (40.77 t/ha), Kufri Ganga (39.34 t/ha), hybrid P-40 (38.7 t/ha), P-27 (38.31t/ha), P-36 (30.76 t/ha) and P-31 (30.46 t/ha) at 75 days is correlated with higher growth and vigor parameters of the plants viz. number of compound leaves, number of stems, canopy cover, height of the plants.

Table 1: Days of emergence and final emergence (%) Number of stems per plant, Plant height and Diameter of stem of different potato hybrids/ varieties

Treatment	Days to emergence	Final emergence (%) at 30DAP	Number of stem/plant at 45 DAP	Plant height (cm) after 45DAP	Diameter of the stem(cm) at 50DAP
MS/11-664	13.17	91.78	5.00	50.90	2.12
CP-4409	10.50	93.11	5.67	53.60	1.97
MS/14-505	11.33	93.78	4.50	56.68	2.15
MS/14-1381	11.83	93.33	4.50	55.00	2.16
MS/13-527	11.50	92.00	6.00	49.13	1.91
Kufri Khyati	11.17	92.22	5.17	51.12	2.09
Kufri Pukhraj	12.50	95.11	4.83	52.58	2.03
Kufri Mohan	13.17	95.11	6.17	48.71	2.07
Kufri Lalit	12.00	93.28	4.67	54.51	1.98
Kufri Sindhuri	12.00	91.78	6.67	54.58	2.11
Kufri Neelkanth	11.83	96.06	5.00	48.88	1.98
Sem+	0.29	1.26	0.36	0.99	0.03
CD (5%)	0.84	N.S.	1.02	2.84	0.10

Table 2: Total number of tubers and total yield of different potato hybrids/ varieties

Treatment	Total number (thousand/ha.)			Total yield (t/ha.)		
	75DAP	90DAP	Senescence	75DAP	90DAP	Senescence
MS/11-664	596.76	683.33	877.78	35.21	47.46	55.99
CP-4409	770.83	807.87	956.48	35.42	43.73	56.46
MS/14-505	923.15	947.22	1208.33	43.11	52.92	73.06
MS/14-1381	961.11	942.13	1135.19	40.95	49.91	71.92
MS/13-527	926.39	923.61	1193.52	35.82	43.26	53.32
Kufri Khyati	804.63	876.39	1073.15	37.93	50.15	64.89
Kufri Pukhraj	935.19	899.07	1087.96	39.60	49.56	58.05
Kufri Mohan	732.87	839.81	1030.56	37.10	49.26	56.00
Kufri Lalit	811.11	737.96	882.41	40.36	44.93	50.90
Kufri Sindhuri	966.20	930.09	1157.41	34.12	38.63	53.30
Kufri Neelkanth	840.74	859.26	990.74	38.30	46.06	56.37
Sem+	46.79	38.92	47.49	1.13	1.42	2.46
CD (5%)	134.01	111.46	136.01	3.25	4.07	7.04

Conclusion

From the present trial it is concluded that at 75DAP hybrid, MS/14-505 recorded (43.11t/ha.) significantly higher tuber yield. At 90DAP hybrid MS/14-505 recorded significantly higher tuber yield (52.92 t/ha.). At senescence, Hybrid MS/14-505 recorded significantly higher tuber yield (73.06 t/ha.). It is also concluded that among controls at 75 DAP Kufri Lalit recorded highest tuber yield 40.36t/ha while at 90DAP and senescence Kufri Khyati recorded highest tuber yield 50.15t/ha. and 64.89t/ha., respectively ratio among controls at 90DAP and senescence, respectively. Hence it is concluded that Hybrid MS/14-505 spotted best among different hybrids and controls followed by hybrid MS/14-1381 for the cultivation of red skinned potatoes in north central plains of India.

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