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Performance of Short-duration Potato (*Solanum tuberosum* L.) Hybrids and Varieties for Growth and Yield Attributing Characteristics in Chambal Region of Madhya Pradesh, 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

A total of thirteen different potato hybrids and varieties grown at ICAR-Central Potato Research Institute-Research Station, Gwalior were evaluated for different growth, morphological, and yield attributes for earliness in Chambal region of Madhya Pradesh. The experiment was laid out in randomized block design in three replications. Statistically non-significant variation was recorded under emergence at 30 days and days to senescence (70% maturity) ranged from 89.33% to 95.11% and 89.7 days to 97.7 days, respectively. A statistically significant effect was recorded under different growth parameters *viz*., day to emergence (days), plant height (cm), number of branches per plant (Stem/plant), number of compound leaves /plant, and plant vigour after 60 days of planting (scale 1-5). Control Kufri Ganga (24.28 t/ha) recorded a significant maximum marketable tuber yield at 60 DAP with a net return of Rs 97224 per ha and a B:C ratio 1:2 followed by Kufri Khyati yielded 23.31t/ha with a net return of Rs 89521 per ha and B:C ratio 1:1.92, Kufri Pukhraj yielded 23.02 t/ha with a net return of Rs 87150 per ha and B:C ratio 1:1.9, hybrid and P-31/J/7-37 & P-36/J/8-91 yields 21.72 t/ha with a net return of Rs 76780 per ha and B:C ratio 1:1.79. At 75 DAP, Kufri Khyati (37.33t/ha) recorded the highest marketable tuber yield with a net return of Rs 192909 per ha and B:C ratio of 1: 2.82 followed by Kufri Ganga (36.33 t/ha) with a net return of Rs 184909 per ha and B:C ratio 1:2.75, Hybrid P-40/J/8-85 (35.65 t/ha) with net return of Rs 179427 per ha and B:C ratio 1:2.70 and P-27/J/-05 (35.35t/ha) with a net return of Rs 177057 per ha and B:C ratio 1: 2.67, were spotted as best for cultivation in the Chambal region of Madhya Pradesh.

Keywords: B: C ratio; early maturing; hybrids; varieties; marketable tuber yield; net return; potato.

1. INTRODUCTION

Potato (*Solanum tuberosum* L.) is an annual herbaceous plant, grown under a diverse range of climatological conditions, having wider adaptability in sowing and harvesting time. The potato crop is indigenous to Peru- the Bolivian region where it is found to be growing as a wild form. The wildest forms of diversity belong to the Nightshade family and were introduced in India in the early 17th century by the Portuguese. India is one of the 2nd largest potato producers contributing nearly 12 % of global production after China [1]. In the country, potato is cultivated in a 2.18-million-hectare area with production of 52.59 million tones and productivity of about 24.08 t/ha [2].

Madhya Pradesh is the 5th largest producer of potatoes in India. The state has taken a large stride in potato production during the last 9-10 years. Area, production, and productivity of potatoes have increased tremendously in MP during the period. The total cultivable area under potatoes increased almost more than double from 62 thousand in 2010-11 to 158.13 thousand ha in 2020-21. In the same period, production increased more than four times from 743 to 3586.76 thousand MT and the productivity almost doubled from 12.0 in 2010-11 to 22.68 MT/ha in 2020-21 [2].

In India, potato is widely grown under varied agro-climatic conditions, based on the tuber maturity period potato cultivars are classified as early, mid, or late-maturing. Early maturing varieties complete their life cycle in about 60 - 75 days [3]. Being a short-duration and fast-growing crop potato is ideal for growing as an intercrop, and generates an enormous opportunity for cultivating potatoes in Asian countries. Early maturing potato varieties which are ready to harvest in about 60-75 days, provide much-needed food before grains are ready. These early maturing features facilitate the potato to incorporate into the cropping system and also fit well in sequential cropping of paddy-potato-wheat during fallow periods, due to its high yield under early (75 days) and very early (60 days) harvest. It has the potential to produce the highest quantity of food per unit of time and area and has high nutritional value for ensuring food security for expanding population [4]. Earliness enables the farmers to take the potato crop anytime for two months, which can solve the problem of storage/glut to some extent and helps to prevent several abiotic and biotic stresses. So, developing early potato hybrids or varieties is most important in the current situation [3].

2. MATERIALS AND METHODS

The experiment was carried out in the experimental area of the ICAR-CPRI-RS, Maharajpura, Gwalior (M.P.) during the *rabi* season of 2019-20 under agro-climatic and soil conditions of Madhya Pradesh. Gwalior is

located at 26˚13' North-latitude and 78˚14' East-longitude and 206 meters above sea mean level lie in the North tract of M.P. enjoying the subtropical climate, with extremely hot about 44.4 ^{o}C in summer and minimum temperature of 3.9 ^{o}C in the winter season. The weather condition was normal during the crop season with an average minimum and maximum temperature during the growing period remaining at 2.5^{o}C and 29.7 ^{o}C, respectively. The total rainfall received from November 2019 to February 2020 was 16.30 mm. The soil of the experimental field was silt clay loam to silt loam having good drainage.

The experimental material comprised 6 Hybrids and 7 controls/checks as treatment, namely hybrids **-** P-27/J/-05, P-29/J/7-15, P-31/J/7-37, P-36/J/8-91, P-40/J/8-85, and P-55/J/10-148, Controls/checks**-** Kufri Khyati, Kufri Lauvkar, Kufri Garima, Kufri Mohan, Kufri Ganga, Kufri Pukhraj, and Kufri Pushkar. These genotypes were raised in a randomized complete block design with three replications. Row to row distance was 0.60 m and plant to plant distance was 0.20 m. The different hybrids and varieties were studied for various growth-related traits including days to emergence, final emergence %, plant height (cm), no. of stems per plant, no. of compound leaf, plant vigor, and days to senescence. Yield attributing data on tuber number and weight/ha were recorded at 60, 75 and at senescence after planting. Tubers were divided into two grades non-marketable tubers (<20g) and marketable tuber (>20 g). Economics was worked out by taking mean tuber yields and the B:C ratio. The data recorded during the course of experimentation were subjected to statistical analysis of Randomized Block Design as described by Panse and Sukhtame [5].

3. RESULTS AND DISCUSSION

The analysis of variance depicted that most of the characters studied under the experiment exhibited a significant mean sum of squares. The mean performance of different parameters with respect to varieties and hybrids are presented in Tables 1 to 4.

3.1 Growth Parameters

The data from Table 1 revealed that days to emergence were found significantly different among different hybrids and varieties. Kufri Mohan (7.33 days) recorded significantly lowest days to emergence over other hybrids and controls but was at par with hybrid P-27/J/-05, P-36/J/8-91, control Kufri Garima, and Kufri Ganga (8 days). Sadawarti et al. [6] concluded that under the Gwalior region condition of central India, Kufri Sindhuri, Kufri Lauvkar, and Kufri Chandramukhi took 11 days for emergence, while Kufri Chipsona-1 took 10 days for emergence, which indicates the significant differences in varieties for days to emergence. Similar variable trend was also observed among hybrids and varieties in the present study.

The data indicated that hybrids and controls did not affect significantly with regard to final emergence at 30 DAP and ranged from 89.33% to 95.11% in the present study. Present results are in accordance with Verma et al. [7], Deshmukh et al. [8], Preetham et al. [9], Sati et al. [10], and Sadawarti et al. [6] who also noted non-significant differences in the final emergence percentage among varieties. Planting of well-sprouted tubers in the present trail resulted in better germination in all the hybrids and varieties.

Plant height per plant was noted as significant for different hybrids and controls. In the present study, all the hybrids and controls *viz.* Kufri Mohan (52.3 cm) followed by Kufri Khyati (50 cm), Kufri Garima (49.9 cm), Kufri Ganga (48.9 cm), hybrid P-27/J/-05 (48.8 cm), Kufri Pushkar (48.0), Kufri Pukhraj (47.0 cm), P-36/J/8-91 (46.2 cm), P-40/J/8-85 (45.0 cm), P-31/J/7-37 (43.7 cm), hybrid P-29/J/7-15 (42.7 cm), and recorded significantly higher plant height over hybrid P-55/J/10-148 (36.2 cm). The maximum plant height was recorded in Kufri Badshah (57.77 cm) followed by Kufri Sadabahar (40.19 cm) reported by Mann et al. [11]. A similar trend was also reported by Khan et al. *[12]*, Preetham et al. [9], Mehara et al. [13], and Agrawal et al. [14]. The present response was also supported by Eaton et al. [15] who reported a difference in the height plant of different potato genotypes and might be due to environmental effects and plant genetic makeup.

The number of branches per plant has been presented in Table-1, it is revealed from the data that hybrids and controls for the number of stems per plant affect significantly. Hybrids P-55/J/10-148 (7.3), P-27/J/-05 (7), Kufri Khyati (7), P-40/J/8-85 (6.7), and Kufri Mohan (6.7) recorded a significantly higher number of branches per plant over hybrids P-36/J/8-91 (5.1), control Kufri Lauvkar (5.3) and Kufri Pukhraj (5.4) and others were at par. Such variations were reported by and in conformity with Mann et al. [11] where

significant maximum stem number was in Kufri Surya (4.90) followed by Kufri Pushkar (3.70), Kufri Badshah (3.63), and Kufri Pukhraj (3.60). Kufri Chipsona-1 (5.3) recorded a significantly higher stem number than Kufri Lauvkar [6]. The present variable response was also supported by Sadawarti et al. [16] and Foroghian et al. [17].

It is revealed from the data (Table 1) that the differences in number of compound leaves per plant were significant for different hybrids and controls. In the present study, control Kufri Khyati (75.3 compound leaves/ plant), Kufri Mohan (74.3 compound leaves/ plant), Kufri Pushkar (72.6 compound leaves/ plant), Kufri Ganga (70.7 compound leaves/ plant), hybrid P-27/J/-05 (70.6 compound leaves/ plant), and P-55/J/10-148 (70 compound leaves/ plant) observed significantly higher number of compound leaves per plant over other hybrids and control except Kufri Garima, which was at par. The present response was supported by Sadawarti et al. [16] who observed that Kufri Sindhuri (59.6) recorded the maximum number of compound leaves/plant whereas the minimum was recorded in Kufri Chandramukhi (44.0). Mishra et al. [18] evaluated thirty-three strains/varieties in the Allahabad region and stated that only ten varieties recorded fewer numbers of leaves whereas numbers of leaves range from 68.50 to 89.33 no. of leaves per plant.

It is evident from the data (Table1) that the differences in plant vigor (1-5 scale) were significant for different treatments. Maximum plant vigor (5) was recorded in hybrid P-40/J/8-85, control Kufri Pushkar, Kufri Garima, and Kufri Pukhraj over hybrid P-27/J/-05(3.7) and P-55/J/10-148(3.3) but was at par with remaining hybrids and controls. Similar findings were reported by Mann et al. [11] where plant vigor ranged from 1.33 (CP 1588) to 3.66 (Kufri Badshah and Kufri Pushkar). Present findings were in accordance with the climatic condition of Rajasthan (Kota) where Kufri Bahar and Kufri Badshah noted higher plant vigor (5) over Kufri Pukhraj (4.33) and Kufri Lauvkar (4), [19].

The data indicated that hybrids and controls did not affect significantly with regard to days to senescence and ranged from 89.7 days to 97.7 days in the present study. Similar trends were also reported by Haile et al. [20] that depending on variety and planting date, the period of vegetation for potato crops varied accordingly and ranged from 90 to 124 days. A similar result was also reported by Agrawal et al. [14] maximum days for maturity observed in Kufri Chipsona-2 (120 days for maturity) and Kufri Chipsona-4 (110 days for maturity). A similar trend was also observed in the present research study.

3.2 Yield Parameters

Non-marketable tuber (<20g) number thousand per hectare: The non-marketable tuber (<20g) number thousand per hectare of different hybrids and controls is affected significantly for different hybrids and controls and given in Table 2. At 60 DAP, hybrid P-40/J/8-85 (632 thousand/ha) followed by Kufri Pushkar (606 thousand/ha) recorded significantly higher non-marketable tuber number over other hybrid and control. Hybrid P-27/J/-05 (559 thousand/ha) and P-36/J/8-91 (511 thousand/ha) recorded significantly higher tuber number over control Kufri Lauvkar, Kufri Garima, Kufri Mohan and Kufri Ganga. At 75 days after planting, Kufri Mohan (665 thousand/ha) and Kufri Pushkar (620 thousand/ha) recorded significantly the highest non-marketable tuber number over other hybrids and control. But among hybrids, P-55/J/10-148 (469 thousand/ha), hybrid P-29/J/7-15 (431 thousand/ha), hybrid P-27/J/-05 (417 thousand/ha) and hybrid P-40/J/8-85 (413 thousand/ha) gave significantly higher non-marketable tuber over control Kufri Lauvkar, Kufri Garima and Kufri Ganga. At senescence, hybrid P-40/J/8-85 (643 thousand/ha) gave significantly the highest non-marketable tuber number over other hybrid and control whereas lowest in hybrid P-31/J/7-37. Solomon et al. [21] found in their study that more numbers of non-marketable tuber yields were obtained from local varieties. The non-marketable number was higher in Belete (136%) and Guassa (157%) as compared to local varieties. A similar variation was also observed in present findings.

Non-marketable tuber (<20g) yield (t/ha): The non-marketable tuber (<20g) yield (t/ha) affect significantly for different hybrids and controls and is given in Table 2. The data revealed that hybrid P-40/J/8-85 (5.63 t/ha) gave significantly higher non-marketable tuber yield over other hybrids and control except Kufri Pushkar. Control Kufri Pushkar (6.34 t/ha) recorded significantly the highest non-marketable tuber yield over other hybrids and control at 60 days after planting. At 75 DAP, significantly higher non-marketable tuber yield was observed in hybrid P-36/J/8-91 (3.71 t/ha) and was at par with control Kufri Khyati and Kufri Pukhraj as compared to other

treatments. But, control Kufri Mohan (5.85 t/ha) and Kufri Pushkar (4.76 t/ha) gave significantly higher non-marketable tuber yield over other hybrids and control. At senescence, hybrid P-36/J/8-91 (5.74 t/ha) recorded significantly the highest non-marketable tuber yield over all other hybrids and controls. Among the control, Kufri Pushkar (5.07 t/ha) recorded significantly higher non-marketable yields over other controls. Sadawarti et al. [22] reported that among varieties at 60 DAP, significantly higher non-marketable tuber yield (t/ha) observed in K. Jyoti, K. Pushkar, K. Badshah, K. Khyati, K. Pukhraj, K. Chipsona-1 and K. Surya over K. Lauvkar (1.29). And at 75 DAP, all varieties except K. Garima and Kufri Jyoti observed significantly higher non-marketable tuber yield (t/ha) over K. Lauvkar (1.05 t/ha). Ebrahim et al. [23] posit that Kellacho local *cv.* recorded the lowest non-marketable tuber number as compared to other two improved varieties i.e., Gudenie and Jalene. Rangare et al. [24] found that among forty-four genotypes, J/92-159 observed highest mean unmarketable tuber yield (2.160 kg/plot) and lowest in MMP/97-625 (0.170 kg/plot). Similar variation was also observed in present findings.

Marketable tuber (>20g) number thousand per hectare: The marketable tuber (>20g) number thousand per hectare of different hybrids and controls is affect significantly as given in Table 2 and Fig.1. At 60 DAP, the significantly highest marketable tuber number was recorded in hybrid P-40/J/8-85 (694 thousand/ha) over the rest of the treatments. Hybrid P-36/J/8-91 (520 thousand/ha) andP-27/J/-05 (487 thousand/ha) also recorded higher tuber as compared to Kufri Mohan, Kufri Lauvkar, and Kufri Garima. Among Control Kufri Khyati (596 thousand/ha) was at par with Kufri Pukhraj (554 thousand/ha) and observed significantly higher marketable tuber number over other controls. At 75 DAP, Kufri Mohan (724 thousand/ha) recorded significantly the highest marketable tuber number over the rest of the treatments. Also, hybrid P-40/J/8-85 (651 thousand/ha) and P-27/J/-05 (653 thousand/ha) gave significantly higher marketable tuber numbers as compared to other hybrids and control Kufri Lauvkar and Kufri Garima. At senescence, control Kufri Mohan (919 thousand/ha) recorded significantly the highest marketable tuber number over other hybrids and controls. But among hybrids, P-40/J/8-85 (715 thousand/ha) followed by P-27/J/-05 (765 thousand/ha) and P-36/J/8-91 (678 thousand/ha) gave higher marketable tuber number over other hybrids and control Kufri Lauvkar only. Singh and Lal [25] reported that as compared to Lal Gulab statistically higher marketable and total tuber numbers were observed in Kufri Surya (243.54 thousand/ha) at the farmer's management level. Gebreselassie et al. [24] noted that at Haramaya, a higher marketable tuber number (%) was found in Gera (95.83%) followed by Zemen (94.25%) and lowest in Bette (67.21%) and Jarso (66.13%) whereas at Hirna, Ararsa (86.02%) recorded a higher marketable tuber no. % and Bule (44.74%) and Jarso (57.72%) recorded the lowest marketable tuber no. %. Similar findings were also reported by Bilate and Mulualem [26].

Marketable tuber (>20g) yield (t/ha): The marketable tuber (>20g) yield (t/ha) of different hybrids and controls is significant and reported in Table 2 and Fig. 1. The data revealed that at 60 DAP, Kufri Ganga (24.28 t/ha), Kufri Khyati (23.31 t/ha) and Kufri Pukhraj (23.02 t/ha) gave higher marketable tuber yield as compared to other. Among hybrid, significantly higher tuber yield was observed in hybrid P-31/J/7-37 & P-36/J/8-91 (21.72 t/ha), over hybrid P-55/J/10-148 and control K. Lauvkar (18.81 t/ha). Whereas, at 75 DAP, control Kufri Khyati (37.33 t/ha), Kufri Ganga (36.33 t/ha), and Kufri Pukhraj (35.41 t/ha) recorded significantly higher marketable tuber yield which was at par with Hybrid P-40/J/8-85 (35.65 t/ha) and P-27/J/-05 (35.35t/ha) as compared to other treatments. While, the lowest marketable tuber yield recorded in hybrid P-55/J/10-148 (23.02 t/ha) which was at par with P-29/J/7-15 (25.37 t/ha) and Kufri Lauvkar (25.17 t/ha). And at senescence, Kufri Khyati (57.59 t/ha), and Kufri Ganga (56.69 t/ha) gave significantly higher marketable tuber yield over the rest of the hybrids and controls. Whereas among hybrids, hybrid P-27/J/-05 (50.31 t/ha) and P-31/J/7-37(50.33 t/ha) recorded significantly higher marketable tuber yield over other hybrids. Variation recorded for marketable tuber yield may be due to environmental factors/genotypes [24]. Current findings are in agreement with Arya et al. [27] concluded that the maximum yield recorded in CIP clone 397006.18 (34.0 tonnes/ha) over the control Kufri Pukhraj (26.8 t/ha) and Kufri Surya (20.2 t/ha). Maan et al. [11] reported that out of twenty genotypes, maximum marketable tuber yield observed in Kufri Pushkar (393.66 q/ha) at par with Kufri Badshah. While the lowest marketable tuber yield recorded in CIP 1588 followed by Kufri Pukhraj (273.74q/ha) and Kufri Khyati (217.77 q/ha). Worku et al. (2018) reported that over the locations and seasons, CIP-396004.337

(337.70 qt./ha) produced a higher marketable tuber yield and the lowest marketable tuber yield produced from CIP-396029.250 (145.60qt./ha). A similar variable trend for different genotypes was also confirmed by Sadawarti et al. [22], Mehara et al. [13], Patel et al. [28] and Chindi *et. al* [29] reported differences in yield due to genetic variability of different genotype which was also confirmed in present result findings.

Total tuber number per hectare: It is revealed from the data (Table 2 and Fig. 2) that the total tuber number per hectare was affected significantly for different treatments. At 60 days after planting, P-40/J/8-85 (1327 thousand/ha) gave the highest tuber number over the rest of the treatments. Also, hybrid -27 (1046 thousand/ha), P-36/J/8-91 (1036 thousand/ha) recorded significantly higher tuber number over control Kufri Lauvkar, Kufri Garima, Kufri Mohan, and Kufri Ganga. At 75 DAP, Kufri Mohan (1389 thousand/ha) recorded a significantly higher total tuber number followed by Kufri Pushkar (1314 thousand/ha) over other hybrids and control. But among hybrids hybrid P-27/J/-05 (1069 thousand/ha) and P-40/J/8-85 (1064 thousand/ha) recorded significantly higher tuber number over other hybrid and control Kufri Lauvkar and Kufri Ganga. And at senescence Kufri Pushkar (1454 thousand/ha) recorded significantly the highest number of tuber/ha over all other controls. Hybrid P-40/J/8-85 (1357 thousand/ha) recorded significantly higher tuber number over other hybrid and control. And minimum total tuber number was observed in Kufri Lauvkar and P-31/J/7-37. Current findings are in agreement with Singh and Lal [25] who got a 5.7% higher total tuber number per hectare as compared to the Lal Gulab variety. Among varieties, Kufri Sindhuri recorded a maximum no. of total tuber no. (670 thousand/ha) over the other three varieties [22]. Also supported by Sadawarti et al. [30] who noted that the mean total tuber number found maximum in the variety Kufri Sindhuri (648 thou/ha) over Kufri Chandramukhi and Kufri Chipsona-1 when planted under west-central Indian condition this for seed production. Similar variations among different genotypes were also recorded in current findings.

Total tuber yield per hectare: It is revealed from the data (table 2 and Fig. 2) that total tuber yield per hectare affect significantly for different treatments. At 60 DAP, Kufri Khyati (28.22 t/ha), Kufri Ganga (28.69 t/ha) and Kufri Pukhraj (28.28 t/ha) recorded significantly higher tuber yield at par with hybrid P-27/J/-05 (25.59 t/ha), P-36/J/8-91 (26.12 t/ha) and P-40/J/8-85 (26.31 t/ha) as compared to other hybrids and controls and minimum tuber yield recorded in hybrid P-55/J/10-148 and Kufri Lauvkar. At 75 DAP also Kufri Mohan (41.26 t/ha) followed by Kufri Khyati (40.77 t/ha), Kufri Ganga (39.34 t/ha), hybrid P-40/J/8-85 (38.7 t/ha), P-27/J/-05 (38.31t/ha), P-36/J/8-91 (30.76 t/ha) and P-31/J/7-37 (30.46 t/ha) recorded significantly superior as compared to rest of the treatment. And at senescence also Kufri Khyati (61.62 t/ha) and Kufri Ganga (60.47 t/ha) at par with Kufri Pushkar (55.16 t/ha) recorded significantly superior over rest of the treatments. But among hybrids, P-27/J/-05 (53.59 t/ha), P-36/J/8-91 (53.36 t/ha), P-40/J/8-85 (52.16 t/ha) and P-31/J/7-37 (52.03 t/ha) recorded significantly higher tuber yield over other hybrids and control Kufri Lauvkar (33.95 t/ha) only. Lemma Tessema et al. [31] 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. [6] who noted that among varieties, for total tuber yield was found significantly higher in K. Sindhuri (29.54 t/ha) over the other three varieties. Luthra et al. [32] 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), possess higher mean total tuber yield as compared to other genotypes under Chhattisgarh region [33]. For total yield, three early maturing (J/9-141, J/7-15, J/7-37) hybrids were found superior in the pune region at 60 and 75 days crop [19]. Current results were conformity with Singh and Lal [25], Deshmukh et al. [8], Sadawarti et al. [22], Sadawarti et al. [30], Eaton et al. [15], Ebrahim et al. [23], Solomon et al. [21], and Kaur and Khurana [34]. 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/J/-05 (25.59 t/ha), P-36/J/8-91 (26.12 t/ha), and P-40/J/8-85 (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/J/8-85 (38.7 t/ha), P-27/J/-05 (38.31t/ha), P-36/J/8-91 (30.76 t/ha), and P-31/J/7-37 (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, and height of the plants.

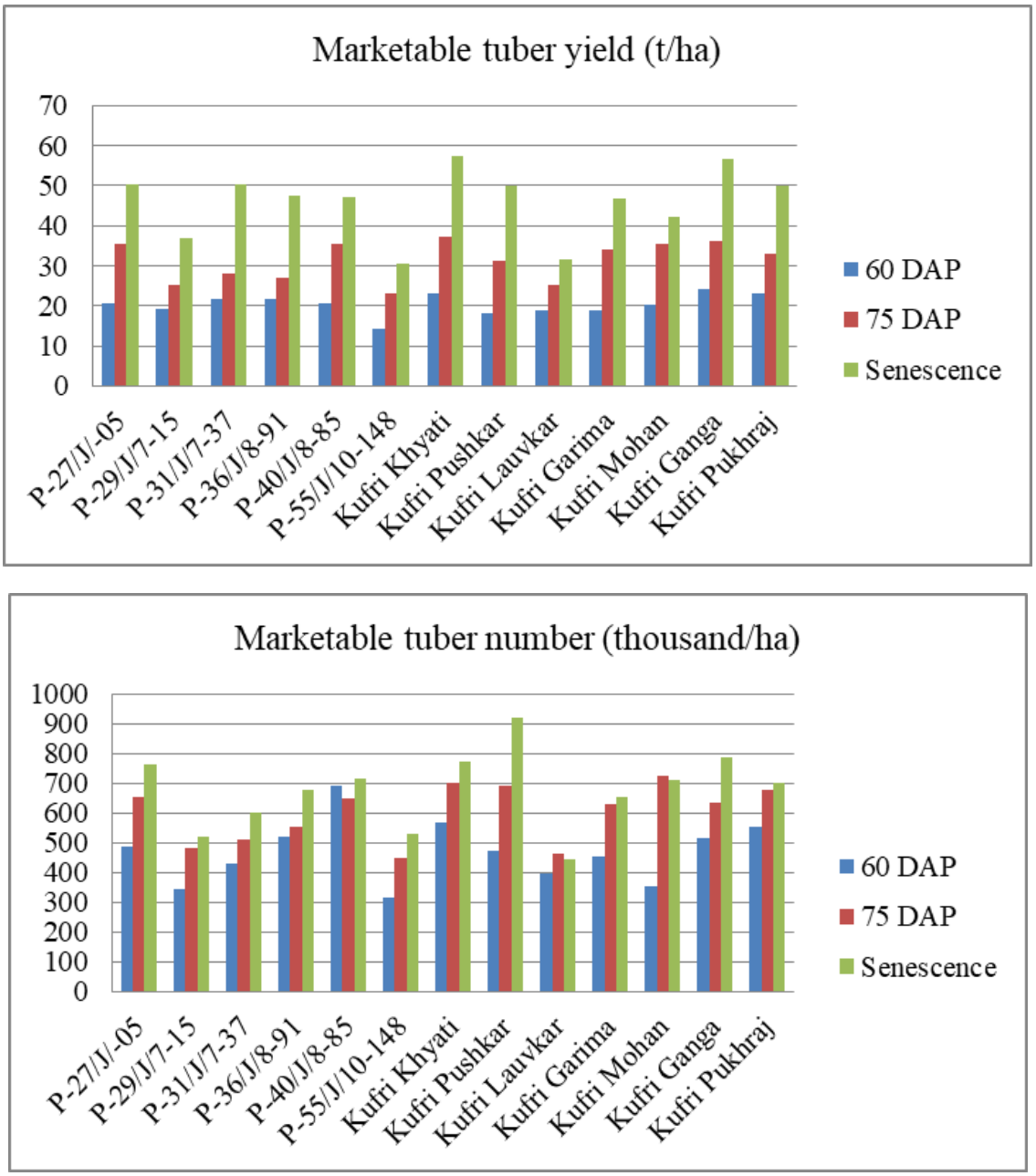


Fig. 1. Marketable tuber number (thousand/ha) and Marketable tuber yield (t/ha) in different harvesting interval as affected by different hybrids and varieties of potato

3.3 Economics

The data related to the economics of different hybrids and controls is portrayed in Table 3 and Fig. 3. From the table, the data revealed that for 60 days crop, among all the hybrids and control gross return, net return and B:C: ratio recorded significant maximum in Kufri Ganga (`194222, `97224 and 2), Kufri Khyati (`186519, `89521 and 1.92) and Kufri Pukhraj (`184148, `87150, and 1.90), P-31/J/7-37 and P-36/J/8-91 (`173778, `76780, and1.79) as compared to rest of the treatments. For 75 days crop, Kufri Khyati (`298667, `192909, and 2.82), Kufri Ganga (`290667, `184909, and 2.75), and Kufri Mohan (`283259, `177501, and 2.68) gave maximum gross return, net return, and B:C ratio over other hybrids and control. But among hybrids, P-40/J/8-85 (`285185, `179427, and 2.7) and P-27/J/-05 (`282815, `177057, and 2.67) gave maximum gross return, net return, and B:C ratio over rest of the hybrids and control Kufri Lauvkar,

Kufri Pushkar, Kufri Garima, and Kufri Pukhraj. Similar findings have been reported by Singh and Lal [25] reported that Kufri Surya recorded maximum gross as well as net returns at improved management practices. Sadawarti et al. [22] reported that higher gross, net return, and B:C ratio were recorded in Kufri Pukhraj, Kufri Khyati, and Kufri Pushkar for 60, 75 and 90 days crops under varied climatic conditions in North-Central India. Present findings were also supported by Raj et al. [35] and Singh et al. [36][37].

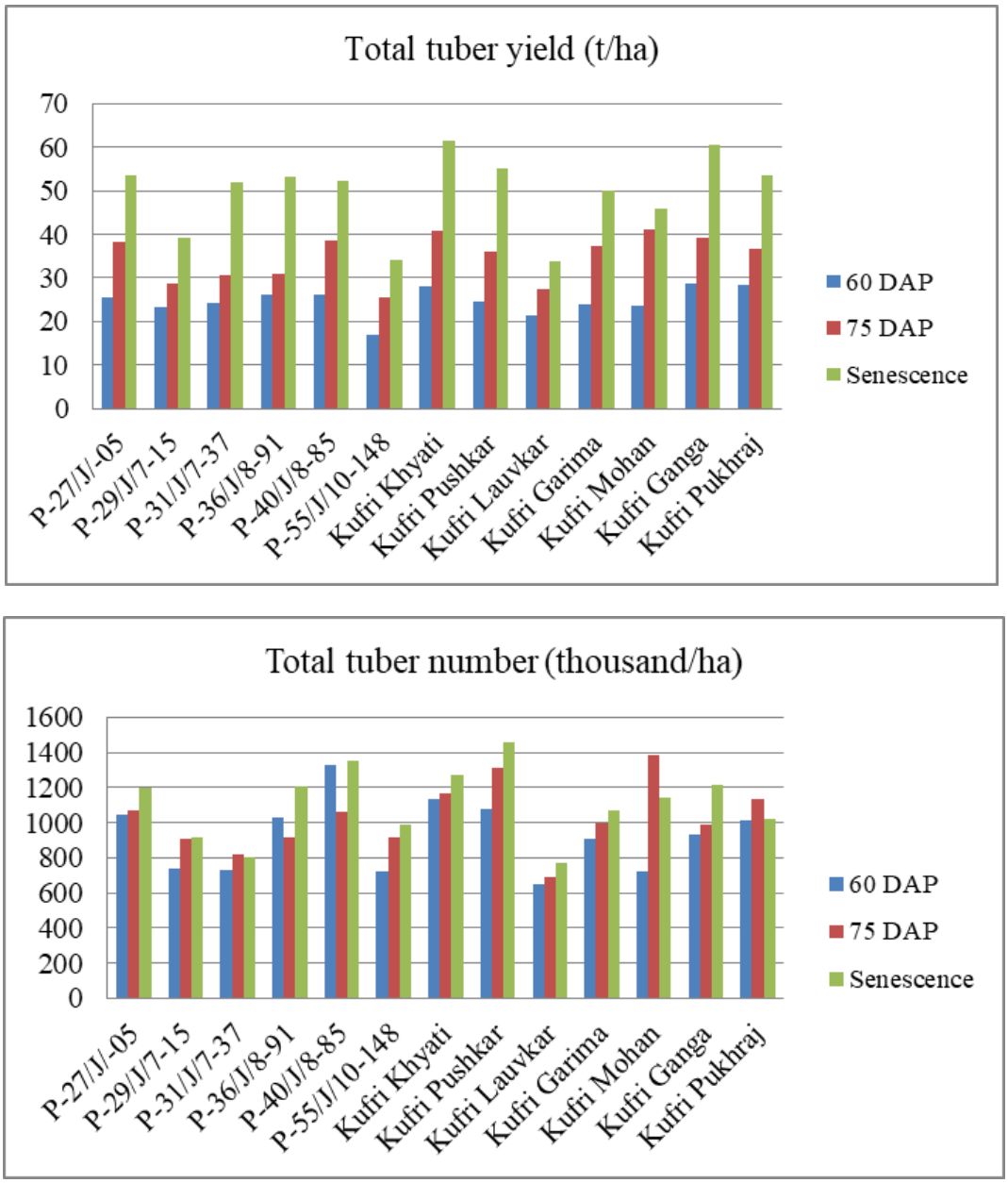
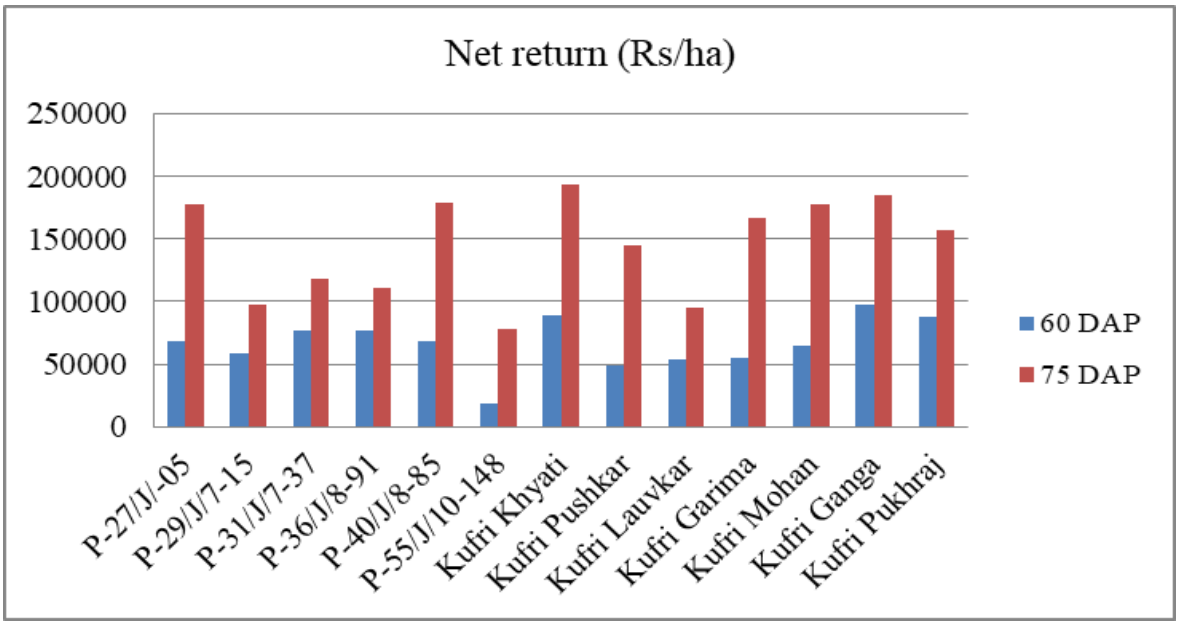


Fig. 2. Total tuber number (thousand/ha) and Total tuber yield (t/ha) in different harvesting interval as affected by different hybrids and varieties of potato



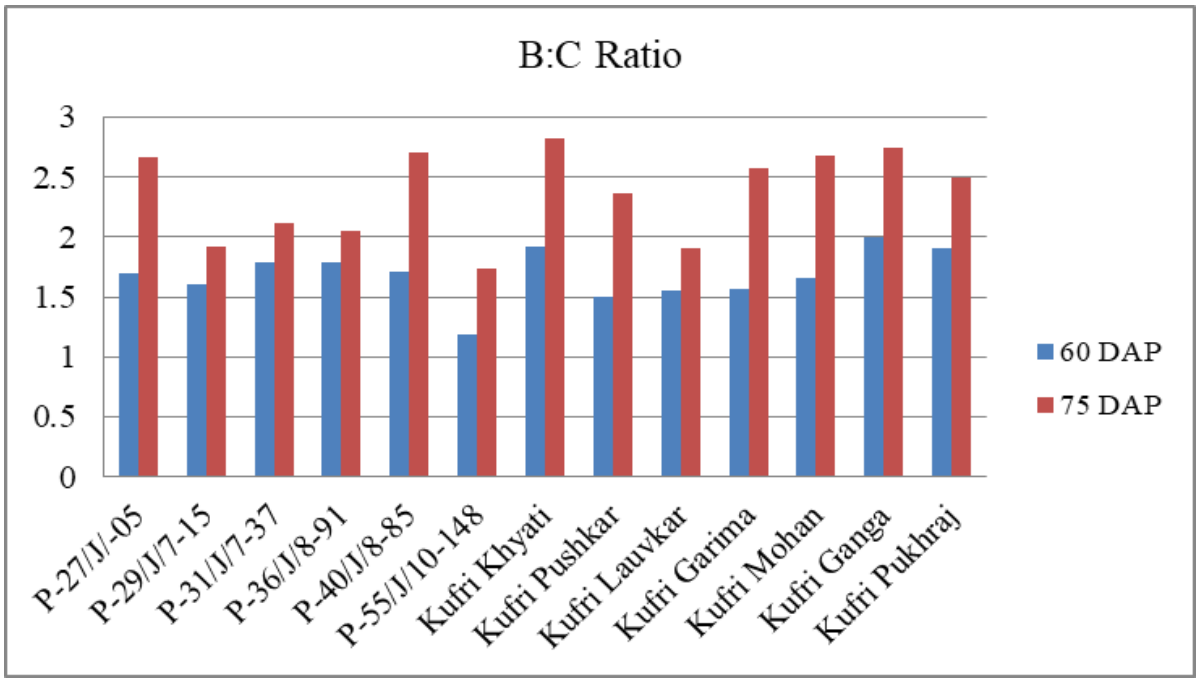


Fig. 3. Net return (Rs/ha) and Benefit: Cost Ratio and of different hybrids and varieties of potato at 60 DAP and 75 DAP

Table 1. Performance of different short-duration potato hybrids and varieties for different growth parameters

S.N.	Treatments	Day to emergence (days)	Germination after 30 days of planting (%)	Plant height (cm)	Number of branches per plant (Stem/plant)	Number of compound leaves /plant	Plant vigour after 60 days of planting (scale 1 - 5)	Days to senescence (70%maturity)
1	P-27/J/-05	8	93.33	48.8	7	70.6	3.7	93.7
2	P-29/J/7-15	8.67	95.11	42.7	5.6	49.9	4.3	92.3
3	P-31/J/7-37	10	93.33	43.7	6.1	59.1	4.7	96.3
4	P-36/J/8-91	8	94.67	46.2	5.1	54.8	4.3	94.3
5	P-40/J/8-85	9	93.33	45	6.7	61.2	5	93.7
6	P-55/J/10-148	8.33	89.33	36.2	7.3	70	3.3	97.7
7	Kufri Khyati	8.33	92	50	7	75.3	4.7	97
8	Kufri Pushkar	8.33	92.89	48	6.6	72.6	5	93
9	Kufri Lauvkar	9	92.44	46.3	5.3	58.4	4.3	89.7
10	Kufri Garima	8	89.33	49.9	6.2	66.6	5	95
11	Kufri Mohan	7.33	90.67	52.3	6.7	74.3	4.7	95.3
12	Kufri Ganga	8	93.78	48.9	5.9	70.7	4.7	92.7
13	Kufri Pukhraj	8.33	91.11	47	5.4	62.1	5	94.3
	S.E.(m)±	0.312	1.354	1.42	0.428	2.663	0.23	1.678
	C.D. (at 5%)	0.917	NS	4.168	1.255	7.818	0.674	NS

Table 2. Performance of different short-duration potato hybrids and varieties for yield attributing parameters at different harvesting intervals

S. N.	Treatments	Non- marketable tuber number (thousand/ha) at			Non- marketable tuber yield (t/ha) at			Marketable tuber number (thousand/ha) at			Marketable tuber yield (t/ha) at			Total tuber number (thousand/ha) at			Total tuber yield (t/ha) at		
		60 DAP	75 DAP	Senescence	60 DAP	75 DAP	Senescence	60 DAP	75 DAP	Senescence	60 DAP	75 DAP	Senescence	60 DAP	75 DAP	Senescence	60 DAP	75 DAP	Senescence
1	P-27/J/-05	559	417	433	5	2.95	3.29	487	653	765	20.59	35.35	50.31	1046	1069	1198	25.59	38.31	53.59
2	P-29/J/7-15	390	431	400	3.87	3.2	2.04	347	481	519	19.41	25.37	37.03	737	912	919	23.28	28.57	39.07
3	P-31/J/7-37	303	309	204	2.48	2.48	1.7	430	510	602	21.72	27.98	50.33	732	819	806	24.2	30.46	52.03
4	P-36/J/8-91	511	356	526	4.4	3.71	5.74	520	556	678	21.72	27.07	47.63	1031	913	1204	26.12	30.79	53.36
5	P-40/J/8-85	632	413	643	5.63	3.06	5.05	694	651	715	20.69	35.65	47.11	1327	1064	1357	26.31	38.7	52.16
6	P-55/J/10-148	409	469	463	2.67	2.62	3.62	316	449	530	14.37	23.02	30.56	725	919	993	17.04	25.64	34.18
7	Kufri Khyati	566	463	500	4.91	3.44	4.03	569	701	772	23.31	37.33	57.59	1134	1164	1272	28.22	40.77	61.62
8	Kufri Pushkar	606	620	535	6.34	4.76	5.07	473	694	919	18.17	31.35	50.09	1079	1314	1454	24.51	36.11	55.16
9	Kufri Lauvkar	253	231	324	2.52	2.13	2.26	398	462	446	18.81	25.17	31.69	651	694	770	21.33	27.3	33.95
10	Kufri Garima	453	368	419	4.93	3.27	3.45	454	632	654	18.98	34.07	46.68	906	1000	1072	23.91	37.34	50.14
11	Kufri Mohan	369	665	426	3.39	5.85	3.59	352	724	713	20.19	35.41	42.25	720	1389	1139	23.57	41.26	45.84
12	Kufri Ganga	417	355	430	4.42	3.01	3.78	515	634	789	24.28	36.33	56.69	931	989	1219	28.69	39.34	60.47
13	Kufri Pukhraj	460	454	320	5.26	3.63	3.8	554	678	700	23.02	32.89	49.83	1014	1131	1020	28.28	36.52	53.63
	S.E.(m)±	15.576	14.61	20.37	0.17	0.106	0.13	77.859	50.62	26.61	1.084	0.921	2.132	33.183	23.844	34.358	1.049	0.907	2.102
	C.D. (at 5%)	45.734	42.9	59.811	0.499	0.312	0.381	26.517	17.24	78.131	3.183	2.704	6.26	97.43	70.011	100.883	3.081	2.664	6.171

Table 3. Gross return (Rs /ha), net return (Rs /ha), and B:C Ratio of different short-duration potato hybrids and varieties

S.N.	Treatments	Gross income (Rs/ha)		Net return (Rs/ha)		B:C Ratio	
		60 DAP	75 DAP	60 DAP	75 DAP	60 DAP	75 DAP
1	P-27/J/-05	164741	282815	67743	177057	1.7	2.67
2	P-29/J/7-15	155259	202963	58261	97205	1.6	1.92
3	P-31/J/7-37	173778	223852	76780	118094	1.79	2.12
4	P-36/J/8-91	173778	216593	76780	110835	1.79	2.05
5	P-40/J/8-85	165481	285185	68483	179427	1.71	2.7
6	P-55/J/10-148	114963	184148	17965	78390	1.19	1.74
7	Kufri Khyati	186519	298667	89521	192909	1.92	2.82
8	Kufri Pushkar	145333	250815	48335	145057	1.5	2.37
9	Kufri Lauvkar	150519	201333	53521	95575	1.55	1.9
10	Kufri Garima	151852	272593	54854	166835	1.57	2.58
11	Kufri Mohan	161481	283259	64483	177501	1.66	2.68
12	Kufri Ganga	194222	290667	97224	184909	2	2.75
13	Kufri Pukhraj	184148	263111	87150	157353	1.9	2.49

4. CONCLUSION

From the present investigation, it can be concluded that among the different hybrids and controls, a significantly maximum marketable tuber yield at 60 DAP was obtained in control Kufri Ganga (24.28 t/ha) with a net return of Rs 97224 per ha and C:B ratio 1:2 followed by Kufri Khyati yielded 23.31t/ha with a net return of Rs 89521 per ha and C:B ratio 1:1.92, Kufri Pukhraj yielded 23.02 t/ha with a net return of Rs 87150 per ha and C:B ratio 1:1.9, hybrid and P-31/J/7-37 & P-36/J/8-91 yields 21.72 t/ha with a net return of Rs 76780 per ha and C:B ratio 1:1.79. At 75 DAP, Kufri Khyati (37.33t/ha) recorded the highest marketable tuber yield with a net return of Rs 192909 per ha, and C:B ratio 1: 2.82 followed by Kufri Ganga (36.33 t/ha) with a net return of Rs 184909 per ha and C:B ratio 1:2.75, Hybrid P-40/J/8-85 (35.65 t/ha) with a net return of Rs 179427 per ha and C:B ratio 1:2.70 and P-27/J/-05 (35.35t/ha) with a net return of Rs 177057 per ha and C:B ratio 1: 2.67, were spotted as best for cultivation in Chambal region of Madhya Pradesh.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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