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Screening of Potato Cultivars under Saline Soil of Canning, West Bengal

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A field trial was conducted to judge the agronomic performances of potato cultivars in saline soil during the winter seasons of 2022-23 and 2023-24 with six potato cultivars *i.e.*, Kufri (K.) Khyati, Kufri Lima, Kufri Himalini, Kufri Mohan, Kufri Ganga and Kufri Jyoti (Local check) under four replications in a randomized complete block design at farmer's field in Canning-I block of West Bengal. The EC values of the coastal soil increased (from ~1 to ~4.0 dS m^{-1}) invariably during the experimental season *i.e.*, from November to March for both the years of experimentation. Among the tested cultivars, K. Lima, and K. Jyoti followed by K. Himalini recorded significantly better growth attributes (plant height, number of compound leaves plant^{-1} and number of stem plant^{-1}) at 60 days after planting (DAP) and total tuber yield (26.0 and 29.8, 26.0 and 31.0, and 24.0 and 31.0 t ha^{-1} during 2022-23 and 2023-24 for K. Lima, K. Jyoti and K. Himalini, respectively). Plant vigour at 90 DAP was found to vary between good and excellent for all the tested potato cultivars. The maximum and minimum extent of leaf senescence at 90 DAP occurred in the case of K. Mohan and K. Himalini, respectively. Skin colour, flesh colour and tuber shape varied among tested cultivars and matched with true genetic character. These three cultivars can be recommended for the coastal saline zone of the state and in other areas having similar climatic and soil conditions.

(***Key words:*** *Potato cultivars, Salinity, Tuber quality, Yield*)

Potato (*Solanum tuberosum* L.) is a major food crop in India. Besides consumption as fresh, it is processed into different products both for human consumption and industrial use. Potato is cultivated in India covering 2.15 million hectares, with an annual production of 54.23 million tonnes (FAOSTAT, 2021). The state of West Bengal is the second largest producer of potato (after Uttar Pradesh) with an annual production of 14.87 M t from 5.01 Lakh ha and an average productivity of 29.65 t ha^{-1} (GoWB, 2023). During the winter season, potato cultivation is seen almost in every Southern district of West Bengal. However, the area of potato cultivation in South 24 Parganas district is still very meagre (3349 ha during 2020-21), accounting for only 0.73% of total potato growing areas of the state (GoWB, 2021), due to salinity stress. The high level of salinity during the crop season is one of the major challenges for potato production in this part of the state. Chourasia *et al.* (2021) also cautioned that increasing the incidence of abiotic stresses due to climate change, such as salinity could limit potato production and productivity. The reduction in tuber yield is commonly seen in saline tracts and the magnitude depends on crop duration, severity of salt stress, and crop growth stage (Sanwal *et al.,* 2022). They further opined that during the initial stage of crop growth, salt stress is more harmful due to the reduced carbon assimilation rate and assimilates partitioning to the tubers. Salt stress at toxic levels reduces the number of leaves, leaf water potential, chlorophyll content, stem number and dry matter ultimately affecting the tuber yield (Chakraborty *et al.,* 2020; Sanwal *et al.,* 2022). However, the interest in potato cultivation has recently gained momentum among the farmers in South 24 Parganas district owing to the higher demand and productivity of table potatoes. Hence, spatial variability of soil salinity across coastal belts could be taken into consideration for potato cultivation. Salinity levels in some areas are high ($EC_e > 4$ dS m^{-1}) whereas some areas have medium (EC_e 2-4 dS m^{-1}) to low ($EC_e < 2$ dS m^{-1}) saline soils where potato cultivation could be explored with location-specific agronomic intervention to deal with salinity stress. But to date, very few interventions

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have been made to grow potato crops under such salt-rich soils. An improved method of potato cultivation under coastal saline soils has been developed (Sarangi *et al.,* 2021). However, to bring potato cultivation forward under low to medium saline conditions, we hypothesized that the selection of suitable cultivars could be crucial for achieving assured and marketable tuber yield.

MATERIALS AND METHODS

Study site

A field trial was set up at a farmer's field in Bodukula village of Canning-I block under South 24 Parganas district of West Bengal (22°13'14.7144"N latitude, 88°35'18.9672"E longitude and 3.52 m above mean sea level) during the winter seasons of 2022-23 and 2023-24. Topographically, the land situation was medium in nature (water stagnation never went beyond 30 cm). The soil texture of the experimental site was clay and the initial soil properties for the 0-30 cm layer are: pH 5.25, organic carbon 1.57%, available N-247.87 kg ha^{-1}, available P_2O_5-226.65 kg ha^{-1} and available K_2O-619.03 kg ha^{-1}. Weather data were logged at ICAR-Central Soil Salinity Research Institute, Regional Research Station, Canning Town, South 24 Parganas, West Bengal during both the cropping seasons. Average weather data for 2 years revealed that the monthly minimum and maximum temperatures fluctuated between 26.25°C and 32.54°C in November, and 14.98°C and 21.61°C in March. The average minimum and maximum relative humidity ranged from 77.61 to 86.58%, and 49.81 and 62.29% during November and March, respectively. An average total rainfall of 38.8 mm was recorded during the cropping season. The monthly average bright sunshine hours day^{-1} was maximum in March (8.52) and minimum in January (3.86). The soil electrical conductivity (EC) values clearly showed that there was a significant increase in soil salinity levels as the dry season progressed, being lowest in November and highest in March during both the years of study (Fig. 1).

Experimental design and inputs

The experiment was conducted in a randomized complete block design (RCBD) with six potato varieties planted under four replications with a plot size of 25 m^2 (5m × 5m). The treatments consisted of six potato cultivars *i.e.*, K. Khyati, K. Lima, K. Himalini, K. Mohan, K. Ganga and K. Jyoti (Local check). The

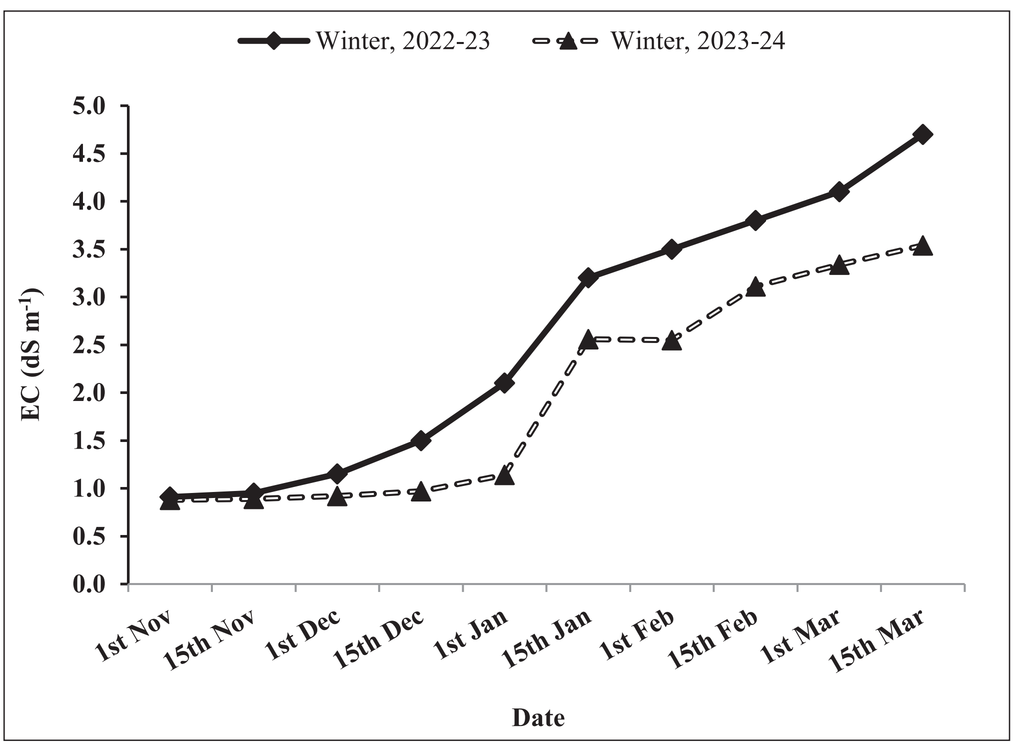

Fig. 1. *The changes of soil EC over the entire crop growth period*

Table 1. *Special characteristics of different potato cultivars*

Name of the cultivars	Characteristics	Yield potential (t ha^{-1})	Reference
Kufri Khyati	Early maturity (Duration 80-90 days); moderately resistant to late blight	15-28	Mondal *et al.* (2015); Mondal *et al.* (2023)
Kufri Lima	Early maturity (Duration 70-80 days); heat tolerant variety; resistant to PVX and PVY; possesses tolerance to hopper and mite burn	30-35	Chattopadhyay *et al.* (2019)
Kufri Himalini	Late maturity (Duration 110-120 days); highly resistant to late blight	27-29	Mondal *et al.* (2015); Mondal *et al.* (2023)
Kufri Mohan	Medium maturity (Duration 90-100 days); field resistant to late blight	35-40	Chattopadhyay *et al.* (2019)
Kufri Ganga	Early maturity (Duration 75-90 days); possesses field resistance to late blight	35-40	Chattopadhyay *et al.* (2019)
Kufri Jyoti (Local check)	Medium maturity (Duration 90-100 days); susceptible to late blight disease	25-30	Mondal *et al.* (2015); Mondal et al. (2023)

quality seed materials were collected from AICRP on Potato Center, Directorate of Research, BCKV, Mohanpur, West Bengal. Special characteristics of these cultivars are given in Table 1.

Cultural practices

The experimental field was well prepared by three times tilling using a tiller. Seed tubers were planted on 19th December in 2022 and 21st December in 2023 with the recommended seed rate of 2 t ha^{-1} following 60 cm (row to row) × 20 cm (plant to plant) spacing. Before planting, cut tubers were dipped in Mancozeb 75% WP solution (@ 2.5 g L^{-1} of water) for 10 minutes. All the cultivars received the recommended fertilizer dose of 200:150:150 kg of N:P_2O_5:K_2O ha^{-1}, respectively through urea, single super phosphate (SSP) and muriate of potash (MoP). Basal application of half dose of N and full doses of P_2O_5 and K_2O was done at final land preparation (just before seed sowing). The remaining half amount of N was top-dressed at 30 days after planting (DAP) followed by earthing up. All the potato cultivars received three irrigations (two from canal and one from pond) at 30, 60 and 75 DAP. Weed infestation in the experimental field was quite low, except minimum existence of *Cynodon dactylon* (Bermuda grass) and *Alternanthera philoxeroides* (Alligator weed). Hand weeding once at 55 DAP (just before 2nd irrigation) was effective against those weeds and made the field almost weed-free. Prophylactic spray of Mancozeb was done once at 65 DAP @ 2.5 g L^{-1} of water to protect the crop against late blight disease. Attack of semilooper was controlled by the spray of Profenofos 40% + Cypermethrin 4% EC @ 2 ml L^{-1} of water at 50 DAP. All the cultivars were harvested on the 16th and 15th of March in 2023 and 2024, respectively by opening the crop line with a country plough, after complete senescence of above-ground plant parts.

Statistical analysis

The experimental data were analyzed by the analysis of variance (ANOVA) using the STAR software version 2.0.1 (IRRI, 2014). The significant difference between the treatment means was tested by critical difference (CD) values at $p<0.05$. The Excel software (version 2010, Microsoft Inc., WA, USA) was used to draw graphs and figures.

RESULTS AND DISCUSSION

Plant growth attributes

Data on growth attributes namely plant height, number of compound leaves plant^{-1} and number of stems plant^{-1} of tested potato cultivars were recorded at 60 DAP (Table 2). There was a significant difference in plant height of tested potato cultivars. The cultivar K.

Khyati attained maximum height (46.3 and 50.1 cm in winter 2022-23 and 2023-24, respectively) at 60 DAP, but it had no significant ($p<0.05$) difference from that of K. Himalini (42.3 and 43.4 cm in winter 2022-23 and 2023-24, respectively). The plant height at 60 DAP was significantly lowest in case of K. Jyoti (30.7 and 31.9 cm in winter 2022-23 and 2023-24, respectively). The difference between tested cultivars was non-significant with respect to the number of compound leaves plant^{-1}. However, K. Ganga produced the maximum number of compound leaves plant^{-1} at 60 DAP (21.7 and 23.4 in winter 2022-23 and 2023-24, respectively) followed by K. Mohan (20.7 and 22.2 in winter 2022-23 and 2023-24, respectively). Despite a lack of significant difference among the tested cultivars in terms of the number of stems plant^{-1}, K. Jyoti produced a maximum number of stems plant^{-1} (3.3 and 3.7 in winter 2022-23 and 2023-24, respectively) followed by K. Ganga (2.7 and 3.1 in winter 2022-23 and 2023-24, respectively) at 60 DAP (Table 2). This result suggests that factors like high light intensity, optimum temperature, absence of water and salt stress, particularly in the early part of the winter season, effectively supported plant growth of all the cultivars (Banerjee *et al.,* 2016a).The differences in growth attributes among tested cultivars might have been caused due to salt stress. Abdelsalam *et al.* (2021) also opined that salt stress adversely affects the growth and development of potatoes by reducing traits like shoot length, plant height and number of branches. Such a decrease in plant growth may occur due to excess accumulation of salts around the root zone (Greene *et al.,* 2016). Other investigators also had the same opinion that salt stress at toxic levels reduces the number of leaves, senescence, leaf area, leaf growth and stem number (Acosta-Motos *et al.,* 2017; Chakraborty *et al.,* 2020; Sanwal *et al.,* 2022). Moreover, limited potato canopy growth irrespective of cultivars was attributed to the low N-status of experimental soil (247.87 kg N ha^{-1}) (Banerjee *et al.,* 2016b). Relatively less growth of certain potato cultivars in the present study (K. Mohan) clearly depicts the fact that a negative correlation of salt stress with plant growth and development exists which is due to the accumulation of toxic ions (Sanwal *et al.,* 2022). The salinity stress also causes nutrient imbalances as well as reduced availability of essential nutrients (especially potassium) under salinity stress, thereby inhibiting the uptake of essential nutrients via roots (Negrão *et al.,* 2017). Such observation also highlights the essentiality of precision agronomic management starting from sowing to harvesting (Das *et al.,* 2016).

Grade-wise tuber production *vis-à-vis* marketable and non-marketable tubers

After harvesting, potato tubers were grouped into four grades, namely 0-25 g, 26-50 g, 51-75 g and >75 g. Then the tubers under each grade were counted and weighed separately (Table 2). Tubers of 0-25 g size were produced only by K. Khyati (5 nos. plant^{-1}) and K. Ganga (3 nos. plant^{-1}) during the winter of 2022-23, which was undesirable from an economic point of view (non-marketable). Other cultivars did not produce any tubers of this grade during winter 2022-23. However, during winter 2023-24, all the cultivars produced non-marketable tubers (0-25 g), and again K. Khyati produced the highest number of non-marketable tubers (6 nos. plant^{-1}) followed by K. Ganga (4 nos. plant^{-1}). On the other hand, cultivars K. Mohan and K. Ganga produced the maximum number of tubers plant^{-1} under each of 26-50 g, 51-75 g and >75 g grades during both years. At harvest, the total tuber number plant^{-1} was significantly higher in case of K. Ganga (14 and 16 in winter 2022-23 and 2023-24, respectively) followed by K. Khyati, K. Mohan and K. Jyoti with at least 10 tubers per plant in both the years. There was no significant difference among the cultivars for total tuber weight of grade 26-50 g in both the years and of grade >75 g in winter 2023-24 only. The weight of grade 51-75 g tubers was significantly ($p<0.05$) higher (110 and 124 g plant^{-1} in winter 2022-23 and 2023-24, respectively) for K. Himalini than that of other tested cultivars. Significant ($p<0.05$) difference was observed among the tested potato cultivars with respect to the total weight of grade >75 g tubers plant^{-1} in winter 2022-23 (Table 2). Both K. Lima and K. Jyoti recorded significantly higher total weight (180 g plant^{-1}) of grade >75 g tubers in winter 2022-23.

Total tuber production

A significant difference ($p<0.05$) existed among the tested potato cultivars for total tuber yield in both the years of study (Table 2, Fig. 2). The potato cultivars K. Lima and K. Jyoti jointly out-performed all other

Table 2. *Growth attributes and grade-wise tuber production of different potato cultivars*

Cultivars	Plant height (cm) at 60 DAP	No. of compound leave plant^{-1} at 60 DAP	No. of stems plant^{-1} at 60 DAP	No. of tubers plant^{-1} at harvest					Weight (g) of tubers plant^{-1} at harvest				
				Grade 0-25 g	Grade 26-50 g	Grade 51-75 g	Grade >75 g	Total	Grade 0-25 g	Grade 26-50 g	Grade 51-75 g	Grade >75 g	Total
Winter 2022-23													
K. Khyati	46.3	19.0	2.0	5	3	0	2	10	20	50	0	100	170
K. Lima	32.3	17.7	2.3	0	2	2	5	9	0	30	50	180	260
K. Himalini	42.3	17.7	2.3	0	4	3	1	8	0	30	110	100	240
K. Mohan	37.3	20.7	2.3	0	5	4	1	10	0	30	50	100	180
K. Ganga	36.3	21.7	2.7	3	4	5	2	14	8	30	55	100	193
K. Jyoti	30.7	20.3	3.3	0	2	4	4	10	0	30	50	180	260
SEm±	1.37	4.12	0.76	0.37	0.48	0.35	0.62	0.72	1.06	5.18	5.27	5.01	8.94
CD ($p<0.05$)	4.33	NS	NS	1.15	1.52	1.10	1.97	2.28	3.34	NS	16.59	15.77	28.18
Winter 2023-24													
K. Khyati	50.1	20.5	2.2	6	3	2	2	13	18	48	20	140	226
K. Lima	33.4	19.0	2.1	1	3	3	4	11	2	40	56	200	298
K. Himalini	43.4	19.9	2.2	1	6	3	1	11	4	42	124	140	310
K. Mohan	39.3	22.2	2.4	2	5	6	2	15	2	36	64	160	262
K. Ganga	38.4	23.4	3.1	4	5	5	2	16	10	40	60	152	262
K. Jyoti	31.9	21.6	3.7	1	2	5	4	12	4	50	66	190	310
SEm±	1.30	1.25	0.36	0.63	0.48	0.67	0.43	0.88	1.00	2.94	4.84	20.27	16.14
CD ($p<0.05$)	4.08	NS	NS	1.99	1.52	2.13	1.37	2.76	3.15	NS	15.25	NS	49.15

DAP, Days after planting; NS, Non-significant

NB: Number and weight of tubers under first grade (0-25g) was considered as non-marketable grade, while number and weight of tubers under second (26-50g), third (51-75g) and fourth grades (>75g) was considered as marketable grades tested cultivars by producing significantly higher total tuber yield (26.0 t ha^{-1} for both the cultivars) in winter 2022-23. The total tuber yield was slightly low (24.0 t ha^{-1}) in case of K. Himalini in winter 2022-23 but it had no significant difference with that of K. Lima and K. Jyoti. In winter 2023-24, both K. Himalini and K. Jyoti jointly recorded the highest tuber yield (31.0 t ha^{-1}) followed by K. Lima (29.8 t ha^{-1}). Such an increase in yield was nothing but the direct effect of a higher number and weight of bigger size (>75 g) tubers $plant^{-1}$, as obtained in the case of K. Lima, K. Himalini and K. Jyoti. Banerjee *et al.* (2016b) also opined that the number and weight of bigger size tubers determine the total tuber yield of a specific variety of potato. Higher yield of these cultivars may further be attributed to the inherent tolerance mechanism of the plant, as it usually attempts to cope with salinity by excluding and transferring excessive salts to older leaves (Acosta-Motos *et al.,* 2017). In addition to that, macronutrients especially phosphorus and potassium might have played an important role in augmenting tuberization process as well as increasing tuber size and yield (Banerjee *et al.,* 2016b; Das *et al.,* 2016), particularly in P and K-rich experimental soil (available P_2O_5 and K_2O were 226.65 kg ha^{-1} and 619.03 kg ha^{-1}, respectively). Thus, an increase in the number and weight of bigger size tubers per plant under a given edapho-climatic condition can increase the total tuber yield of potato (Bera *et al.,* 2019). This might further be attributed to the efficient translocation of nutrients and photosynthates to the tubers under a congenial environment (Mozumder *et al.,* 2014). The overall results showed that most of the cultivars failed to achieve their potential yield (as given in Table 1) at the experimental site, except K. Lima, K. Himalini and K. Jyoti. This clearly indicated that moisture-stress situation (as the cultivars received only three irrigations) produced less number and weight of tubers per plant, irrespective of different grades (Banerjee *et al.,* 2016b).

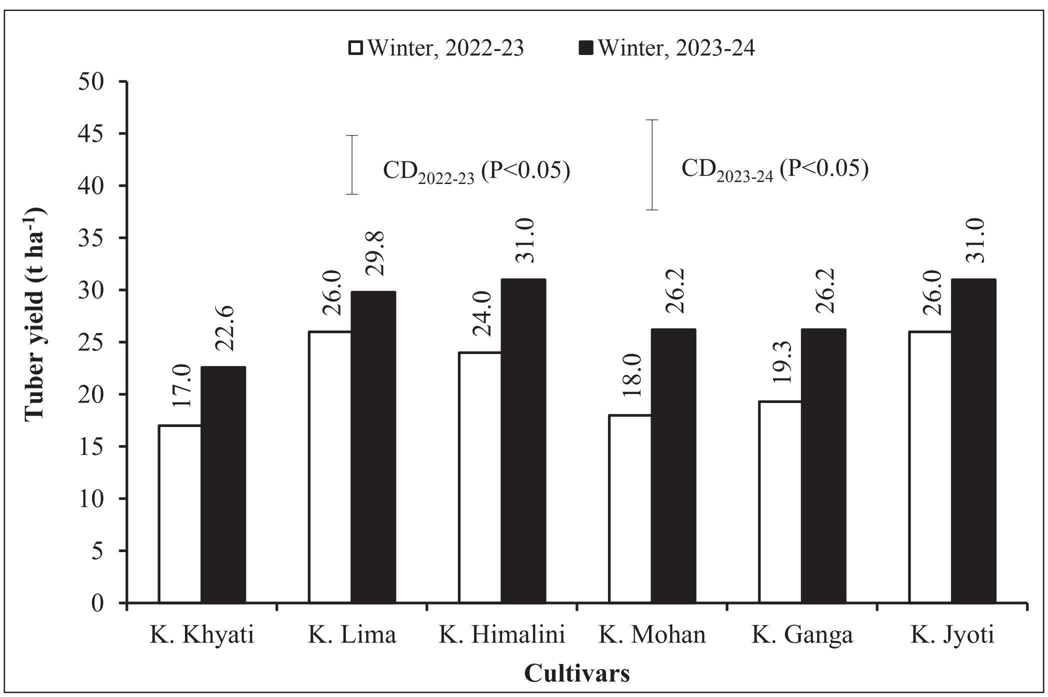

Fig. 2. *Total tuber yield of different potato cultivars*

Higher evaporation loss due to uninterrupted solar radiation on the soil surface and lower water use efficiency (WUE) further affect the tuberization process (Banerjee *et al.,* 2016a). This result also suggests that salinity stress (as represented by higher EC values from February onwards in both the years of study, Fig. 1) might have exerted a detrimental effect on the reproductive growth of the crop, especially on tuberization process. Hence, all the cultivars produced less number and weight of tubers per plant (even below the expected level), except K. Lima and K. Jyoti. This decrease in yield-related traits may occur due to the excess accumulation of salts around the root zone of the plants (Greene *et al.,* 2016). Other investigators also recorded a yield loss of up to 60%, as the tuber numbers, weight of tubers, and total tuber yield were severely affected by salt stress (Hossain *et al.,* 2018; Chourasia *et al.,* 2021).

Plant vigour, senescence and other quality parameters

Plant vigour and senescence of different potato cultivars were recorded at 90 DAP (Table 3). Plant vigour, recorded on a 1-5 scale (where 1 = Poor, 2 = Fair, 3 = Good, 4 = Very good and 5 = Excellent), was found to be very good (≥ 4) to excellent (5) for all the tested potato cultivars. Data on senescence was recorded on the basis of % leaf drying. The extent of leaf senescence was low in case of Kufri Mohan (5 and 10% in winter 2022-23 and 2023-24, respectively) and high in case of Kufri Himalini (30 and 35% in winter 2022-23 and 2023-24, respectively). Other quality traits namely skin colour, flesh colour and tuber shape/ appearance varied from cultivar to cultivar (Table 3) and matched with their true genetic character. This result suggests that soil salinity exerted no deleterious effect on those quality characters. Moreover, there was hardly any difference in the quality traits of any of the tested cultivars over the years. The contribution of quality traits towards total genetic diversity would help in the selection of divergent parents for their use in crop improvement programs.

CONCLUSION

Table 3. *Plant vigour, senescence and other quality parameters of tested potato cultivars*

Cultivar	Plant vigour at 90 DAP		Senescence (%) at 90 DAP		Skin colour	Flesh colour	Tuber shape/ appearance
	Winter 2022-23	Winter 2023-24	Winter 2022-23	Winter 2023-24			
Kufri Khyati	4.0	4.5	10	15	Pale yellow	Light yellow	Oval and medium sized
Kufri Lima	5.0	4.5	20	15	Creamy white	Creamy white	Ovoid and uniform
Kufri Himalini	4.5	5.0	30	35	White	Dull white	Large, oval and smooth
Kufri Mohan	4.5	5.0	5	10	Creamy white	White	Ovoid
Kufri Ganga	5.0	4.5	30	25	Creamy white	Creamy white	Ovoid and uniform
Kufri Jyoti	4.5	4.0	15	20	White	Yellow	Large and oval

DAP - Days after planting; Data of plant vigour was recorded on 1-5 scale [where 1 = Poor, 2 = Fair, 3 = Good, 4 = Very good and 5 = Excellent]; Data on senescence was recorded on the basis of % leaf drying; Skin colour, flesh colour and tuber shape / appearance of each cultivar were same for both the years of study

From this study, it can be concluded that K. Lima, K. Himalini and K. Jyoti proved their superiority over other tested potato cultivars in terms of all measured growth attributes, marketable yield and total tuber yields. Experimental results also suggest that soil salinity of at least up to 4 dS m^{-1} exerted no deleterious effect on quality characters namely skin colour, flesh colour and tuber appearance of above three cultivars. Hence, these identified salt-tolerant cultivars can be recommended for cultivation under medium salinity stress and could be used in hybridization programs for the development of new high-yielding and salt-tolerant breeding lines.

CONFLICTS OF INTEREST

Authors did not have any conflicts of interest for the publication of this research output.

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