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# Performance of potato (*Solanum tuberosum*) advanced hybrid MS/6-1947 under high temperature stress and water deficit conditions

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ABSTRACT

In present investigation, potato (*Solanum tuberosum* L.) advanced stage hybrid MS/6-1947 was evaluated along with controls under high temperature and water stress regimes for three successive winter crop seasons. Under high temperature at Modipuram, MS/6-1947 (13.3 t/ha) showed yield enhancement of 20, 9 and 11% over the controls Kufri Bahar, Kufri Pukhraj and Kufri Surya. It also exhibited at par tolerance to hopper with Kufri Surya and damages due to mite burn were lower than Kufri Bahar and Kufri Pukhraj. The hybrid possessed 18% tuber dry matter. Results on drought toleranceat Modipuram revealed superior performance of MS/6-1947 under normal irrigation, mild water and severe water stress conditions as compared to best control Kufri Pukhraj as yield reduction was comparatively lower under mild and severe water stress treatments. Drought tolerance index (DTI) values were maximum in MS/6-1947 (1.02 and 0.79) followed by Kufri Pukhraj (0.86 and 0.51) and Kufri Bahar (0.72 and 0.58) under mild and severe water deficit treatments, respectively. Drought tolerance studies at Jodhpur revealed better performance of MS/6-1947 under normal and mild water stress conditions as compared to the controls Kufri Pukhraj and Kufri Surya as yield reduction was comparatively lower under mild water stress conditions. DTI values were maximum in MS/6-1947 (1.08) followed by Kufri Puhkraj (1.01) and Kufri Surya (0.41) under mild water deficit treatment. Tuber dry matter content increased under water stress over normal irrigation at both the locations. MS/6-1947 is suitable for table potatoes. MS/6-1947 may be a better option for integrating in cereal based crop sequences, for exploiting its yield potential in early season and for attaining sustainable productivity in areas where high temperature and lower water availability are constraint for raising the successful potato crop.

**Key words:** Drought tolerance, High temperature stress, Night temperature, Potato, Water stress.

Environmental stresses like higher atmospheric temperatures, salinity and drought affect plant growth and productivity in several crop species including potato (*Solanum tuberosum* L.). Negative impact of abiotic stresses (temperature and water) due to changing climate scenario is expected to increase in coming decades on potato production and its extension in non-traditional areas (Hijmanns 2003). High temperature during active crop growth phase is major limiting factor for potato production in many developing countries (Dodds 1990). Reduction in leaf area, tuber number and tuber weight has been reported as symptoms of elevated temperatures during potato growing season (Menzel 1985). Heat stress creates imbalance in source-sink relation, delay in tuber initiation and bulking and malformation and necrosis of tubers (Levy and Veilleux 2007). Optimum temperature for the growth of crop canopy is about 25°C. Minimum night temperature plays a crucial role in tuberization and largely determines whether plant will tuberize or not. Optimum temperatures for tuber formation are widely in the range of 10-17$^0$C (Bodlaender 1963, Moorby and Milthorpe 1975). Normally, tuberization is reduced at higher night temperatures (> 20°C) with complete inhibition of this process above 25°C. A progressive reduction in tuberization is encountered with increasing temperature up to 30°C (Khanna 1966).

Exposure of potato plants to heat stress alters the hormonal balance in the plants and results in partitioning of most of assimilated carbon in favour of above ground vegetative parts at the cost of the tubers. In India, high temperature during crop growth and tuberization restricts adoption of potatoes in early planting conditions of north-western plains and peninsular India (Luthra *et al*. 2006; Luthra *et al*. 2013). Early planted crop is vulnerable to attack of sucking pests like leafhopper (*Amrasca biguttula* Ishida) and mite (*Polyphagotorsonemus latus* Banks) resulting in significant yield reduction (Malik and Luthra 2007, Luthra *et al*. 2013). It is imperative to develop potato clones which could germinate, grow and tuberize well under high night temperatures to mitigate the likely effect of climate change

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and to introduce potato cultivation in non-traditional areas/ seasons, with relatively higher temperature during crop growth period (Luthra *et al*. 2013).

Drought is the most important abiotic stress in agriculture (Cattivelli *et al*. 2008). Potato is susceptible to drought (Yuan *et al*. 2003, Monneveux *et al*. 2013) due to shallow root system, low capacity of recuperation (Iwama and Yamaguchi 2006) and poor soil water extraction (Weitz *et al*. 1994). Drought considered as production constraint of potato worldwide, decreases plant growth (Deblondeand Ledent 2001), tuber set (Lynch and Tai 1989; Struik and Van Voorst 1986), number (Eiasu *et al*. 2007), size of tubers (Schafleitner *et al*. 2007), tuber yield (Rawal *et al*. 2014 and Mahmud *et al*. 2017), loss of tuber quality (Mackerron *et al*. 1988). The magnitude of drought effects depends on timing, duration and severity of the stress. Water stress resistance is defined by Hall (1993) as the relative yield of a genotype compared to other genotypes subjected to the same magnitude of water stress. Water stress-adopted plants are characterized by deep and vigorous root systems. Plants experience water stress by excessive transpiration and/or by a limitation of water supply (French 1997).

A complete mitigation of heat and water stress is impossible. Several potato clones which are relatively able to maintain higher yields at high temperatures have been identified in field evaluation (Levy 1984, Malik *et al*. 1992, Malik and Luthra 2007, Luthra *et al*. 2003; Luthra *et al*. 2013). Similarly, development of potato genotypes having better tolerance to water stress would be a feasible approach to reduce negative effects of water stress on tuber productivity. Identification of drought tolerant genotypes for yield maintenance and breeding purposes is now a priority for improving drought tolerance of potato crop, saving irrigation water, and ensuring yield and food security in changing scenario of global climate and growing demand of water (Luthra*et al*. 2011; Luthra*et al*. 2013. The initial studies on advanced stag hybrid MS/6-1947 suggested that it could be a good choice for heat and water stress regime, therefore, further field evaluation was carried out to assess its yield potential under high temperature and water deficit conditions.

## MATERIALS AND METHODS

The material of present investigation consisted of advanced stage hybrid MS/6-1947 and control varieties Kufri Bahar, Kufri Pukhraj and Kufri Surya. MS/6-1947 with better yielding ability was identified from the cross MS/82-638 × JX 576 (made during 2004-05) in initial investigation conducted during winter crop season of 2007-2008 under reduced irrigation regimes (only three irrigations as against 5-6 irrigation in 90 days). Keeping in view the better yielding ability of MS/6-1947, the experiments were expanded to work out its performance under high temperature stress and reduced water regimes.

The trials were conducted at ICAR-Central Potato Research Institute, Regional Station Modipuram, Meerut, (29° 4' N and 76° 46' E; 237 m above sea level) under early planting conditions for three years during 2010-11 to 2012-13. The advanced stage hybrid MS/6-1947 was evaluated along with control varieties Kufri Bahar, Kufri Pukhraj and heat tolerant variety Kufri Surya in replicated trial (plot size 3.6 $m^2$) planed on 24$^{th}$ of September over the years. The plants were spaced 20 cm within and 60 cm between rows. The crop was dehaulmed 75 days after planting. The recommended cultural practices of the region were adopted for raising the early crop; however application of insecticide was not done in order to allow the population build-up of hopper and mite in the experiments so that tolerant genotypes to these pests could be identified.

The field studies were carried out at Modipuram for three years during 2010-13 in deep loamy soil having neutral pH (7.1), low organic carbon content (0.29%) and available nitrogen (167.1 kg/ha), medium available potassium (117 kg/ha) and high available phosphorous (51.3 kg/ha). Strip-plot design consisting of three replications was adopted for the experiments, where treatments in vertical factor were three irrigation regimes ($I_1$= Normal irrigation, $I_2$= Moderate water deficit, $I_3$= Severe water deficit) and horizontal factor had MS/6-1947 along with controls i.e. Kufri Bahar and Kufri Pukhraj. Under normal irrigations, five irrigations were applied as per requirement, whereas three irrigations were applied in moderate water deficit treatment up to 55 days after planting (DAP) and only two irrigations were given up to 40 DAP in treatment of severe water deficit. Approximately, 50 mm of water was applied in each irrigation by means of conventional ridge and furrow method. Well sprouted seed tubers of 50-60 g seed weight and 40-45 mm in size were planted at a spacing of 60 × 20 cm on 22$^{nd}$ October over the years with plot size of 3.0 × 1.4 m. Uniform fertilizer dose 90-34.4-83.3 kg/ha of N-P- K, and 90 kg/ha of nitrogen was applied before planting and at earthing up (25 DAP), respectively. Recommended schedule of herbicide, fungicides and insecticides application for the region was followed for maintaining proper crop growth. Crop was dehaulmed at 90 DAP and harvested 15 days after proper tuber skin hardening.

The experiment was conducted at farmer field at Jodhpur, Rajasthan (26°17'12" N, 73°01'48" E, 235 m above sea level) under normal and moderate water stress conditions for three years during 2012-15 winter crop seasons. This was an attempt to introduce the potato crop to the hot arid zone of Western India, where water is scarce for field crops, livestock and human beings. Soils of the experimental site were sandy plain with neutral pH (7.05), low organic carbon content (0.31%), available nitrogen (243.6 kg/ha), available potassium (119 kg/ha) and medium available phosphorous (21.4 kg/ha). The advanced stage hybrid MS/6-1947 along with control varieties Kufri Pukhraj (early bulking) and Kufri Surya (heat tolerant) were used for the investigation. Sprouted seed tubers of 40-45 mm size were planted on 5$^{th}$ November over years at 60 × 20 cm distance in a plot size of 4.8 × 1.2 $m^2$. The field experiment was laid out in strip plot design with two irrigation regimes: $I_1$= Normal Irrigation (eight irrigations) and $I_2$ = Deficit irrigation (five

irrigations) as horizontal factor and genotypes as vertical factor. Approximately, 50 mm of water (50 l/$m^3$) was applied in each irrigation by means of conventional method. In both the treatments, two irrigations during emergence phase and one irrigation after earthing up were given. After that, in normal treatment, water was applied at 10 days interval, whereas in deficit irrigation, water was applied at 50 and 70 days. In normal treatment, irrigation was terminated 10 days before dehaulming. There was 2.4 m wide space between and around the treatments to avoid any effect of border soil moisture. Uniform fertilizer dose of 90, 34.4 and 104 kg/ha of N, P, K, respectively, was applied at planting and 90 kg/ha of nitrogen in the form of urea was applied at earthing up time at 25 days after planting. Recommended schedule of herbicide, fungicide and insecticide applications for potato crop was followed for maintaining proper crop growth. The crop was dehaulmed after 90 days of planting and harvested 15 days later after hardening of tuber skin.

Data on damage (%) due to hopper and mite was recorded in early crop planted under high temperature stress. In all trials, at harvest, total and marketable (>20 g) yield were recorded. The estimation of tuber dry matter content (TDMC) was done by selecting five tubers of marketable grade from each plot, which were chopped into small pieces after proper washing and drying at room temperature. A representative sample of 50 g tuber pieces from this sample was drawn and dried in forced hot air draft oven at 80ºC until constant weight was achieved (Luthra *et al*. 2003). Climatic parameters viz. minimum and maximum temperature, sunshine hours and rainfall were recorded from the meteorological laboratory during crop growth period. The day and night temperatures were estimated using Went' equation (1957):

Day temp. = $t^0_{max}$-1/4 ($t^0_{max}$ - $t^0_{min}$); Night temp. = $t^0_{min}$ + 1/4 ($t^0_{max}$ - $t^0_{min}$)

Visual recording of plant vigour on a scale of 1-9 was done at least three places in each plot at 75 days, where, highest and lowest vigour was given a score of 9 and 1, respectively. Plant wilting was observed on a scale of 1-9 at around 1:00 PM at 75 days and score 1 was considered as not wilted, while, 9 was for heavily wilted.

Drought tolerance index (DTI) was calculated using formulae suggested by Hassanpanah (2010):

$DTI = Y_{pt} \times Y_{st} / (Y_p)^2$

where, $Y_{st}$ , Yield of cultivar under moisture stress conditions; $Y_{pt}$ , Yield of cultivar under irrigated conditions; $Y_p$ ; Mean yield of all cultivars under irrigated conditions.

The data was analyzed following standard statistical procedures (Gomez and Gomez 1984).

## RESULTS AND DISCUSSION

*Performance in advanced stage trials at Modipuram*

The clone MS/6-1947 successfully passed through initial evaluation and advanced clonal generations. In advanced generation main crop season yield trial (2009-2010 and 2010-2011) at Modipuram, MS/6-1947 produced significantly higher total tuber yield than the best control Kufri Pukhraj by margin of 15% at 80 days (2009-10), 14% at 75 days and 19% at 90 days.

*Performance under high temperature stress at Modipuram*

The mean maximum and minimum temperatures ranged between 23.02°C and 32.48°C, and 8.67°C to 22.33°C, respectively during crop period (2010-2013). Though the day and night temperature calculated as per formula of Went (1944) reflected reduction of 1.20 to 3.59°C in maximum and augment of 1.20 to 3.59°C in minimum temperature. The night temperature plays an important role during tuberization and night temperature for optimum tuber formation are regarded in the range of 10-17ºC (Bodlaender 1963, Moorby and Milthorpe 1975).The temperature profile of Modipuram revealed prevailing night temperature of 21.65°C during tuber initiation (25 days after planting) and subsequently night temperature in the range of 17.91-21.65°C for about 30 days which are indicative of detrimental effect of high temperature on crop growth and tuberization. The maximum and minimum soil temperatures ranged between 28.86°C and 39.83°C, and 13.84°C to 27.48°C, respectively during crop period. In general, soil temperature was 3.55-7.52°C and 4.36-7.21°C higher than prevailing atmospheric temperature during the crop period. The weather parameters during early planted crop indicates that, minimum soil temperature also play important role in tuberization, though it is dependent on prevailing atmospheric temperature and soil type as well. Night temperature is widely known to impact the tuber initiation, tuberization and bulking of tubers in potatoes, however prevailing minimum soil temperature which remain uninfluenced over longer period seems to be main factor on tuberization in potatoes. Total mean rainfall of 2.52 mm was recorded on three occasions during the crop period. In early planted crop 1351 degree day were recorded. These results indicate that early planted at Modipuram is suitable location for screening of genotypes for heat tolerance.

In general yield of the genotypes under early planting conditions were lower due to prevailing high temperature during planting which affected germination, growth of the plant, tuber initiation and tube development. The pooled result over three years under early planting conditions indicated that MS/6-1947 produced significantly high marketable and total tuber yield than leading variety Kufri Bahar. MS/6-1947 with total tuber yield of 13.3 t/ha showed yield enhancement by margin of 20, 9 and 11% (Table 1) over the controls Kufri Bahar (11.1 t/ha), Kufri Pukhraj (12.3 t/ha) and heat tolerant variety Kufri Surya (12.0 t/ha). MS/6-1947 with 12.3 t/ha marketable tuber yield also showed superiority of 24, 11 and 7% over the Kufri Bahar (9.9 t/ha), Kufri Pukhraj (11.1 t/ha) and Kufri Surya (11.5 t/ha). The potatoes grown under high temperature are also vulnerable to mite and hopper burn. Luthra *et al.* (2013) reported damage due to mite burn (0-30%) and hopper burn (4-86%) on foliage in investigation on 105 potato genotypes. Kufri Surya, the known heat tolerant variety with tolerance to mite and hopper showed damage due to mite (12.13%)

Table 1 Performance of MS/6-1947 in early planting (high temperature) conditions (pooled means of 3 years: 2010-13) at Modipuram

| Genotype | Tuber yield (t/ha) | | Yield increase over controls (%) | | Mite burn (%) | Hopper burn (%) | Tuber dry matter content (%) |
|---|---|---|---|---|---|---|---|
| | Marketable | Total | Marketable | Total | | | |
| MS/6-1947 | 12.3 | 13.3 | | | 24.1 | 5.83 | 17.8 |
| Kufri Bahar | 9.9 | 11.1 | 23.6 | 20.2 | 35.8 | 8.75 | 19.6 |
| Kufri Pukhraj | 11.1 | 12.3 | 10.6 | 8.6 | 35.6 | 7.08 | 16.9 |
| Kufri Surya | 11.5 | 12.0 | 7.1 | 10.6 | 12.1 | 3.08 | 19.4 |
| $CD_{0.05}$ | 2.14 | 2.10 | | | 7.56 | 3.47 | 0.61 |

*Per cent yield increase over respective controls.

and hopper (3.08%) than other varieties. In present study, MS/6-1947 showed at par tolerance (5.83%) to hopper with Kufri Surya (3.08%), though damage due to mite burn were on higher side (24.08%) as compared to Kufri Surya (12.13%), but still less than the most popular variety of the region Kufri Bahar (35.79%) and Kufri Pukhraj (35.63%). MS/6-1947 possessed 17.82% tuber dry matter and was found to be suitable for consumption as table potatoes.

*Performance under water deficit conditions at Modipuram*

Maximum and minimum temperatures during the potato growing season (2010-13) ranged between 16.81-29.17°C and 6.52-15.36°C, respectively. Total mean rainfall of 25.27 mm was recorded on two occasions during the crop period. The maximum and minimum soil temperatures ranged between 15.93°C and 34.62°C, and 8.19°C to 21.76°C, respectively during crop period. In general soil temperature was 2.95-6.36°C and 2.63-7.21°C higher than prevailing atmospheric temperature during the crop period. During water deficit trial at Modipuram, 1044 accumulated degree day were recorded.

Drought tolerance investigation showed significant difference between genotypes and irrigation levels for tuber yield and tuber dry matter content (Table 2). The advanced stage hybrid MS/6-1947 outperformed under normal irrigation, mild water stress and severe water stress conditions as compared to the best control Kufri Pukhraj as yield reduction was comparatively lower in MS/6-1947 under mild water stress and severe water stress conditions. MS/6-1947 with marketable yield 48.0 t/ha and total tuber yield of 51.1 t/ha showed yield enhancement over Kufri Bahar (26% and 11%) and Kufri Pukhraj (27 and 13%) under normal irrigation. Under mild water stress conditions, MS/6-1947 produced significantly high marketable (38.3 t/ha, 4% higher) and total tuber (41.2 t/ha, 5% higher) yield than the best control Kufri Pukhraj (36.7 and 39.2 t/ha). The yield enhancement in MS/6-1947 for marketable (38.3 t/ha, 10%) and total tuber yield (41.2 t/ha, 11%) was significantly high than the Kufri Bahar (34.9 and 37.2 t/ha) leading variety of the region. Results under sever water stress conditions showed the yield enhancement in MS/6-1947 for marketable (29.7 t/ha, 19%) and total tuber yield (32.1 t/ha, 23%) statistically superior to Kufri Bahar (23.7 and 26.1 t/ha). Similarly, significant enhancement in MS/6-1947 for marketable (29.7 t/ha, 19% higher) and total tuber yield (32.1 t/ha, 21% higher) was recorded as compared to best control Kufri Pukhraj (24.9 and 26.6 t/ha). In contrast to decrease in yield due to mild or sever water stress, tuber matter content increased in all the genotypes (Table 2). MS/6-1947 showed at par tuber dry matter content with Kufri Pukhraj under different water regimes. Kumar *et al.* (2007), Jose and Awan (2008) and Rawal *et al*. (2014) also

Table 2 Mean tuber yield and tuber dry matter content of MS/06-1947 under different irrigation regimes (Pooled mean of 3 years: 2010-13) at Modipuram

| Genotype | Tuber yield (t/ha) | | | | | | | | Tuber dry matter content (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Marketable | | | | Total | | | | | | | |
| | $I_1$ | $I_2$ | $I_3$ | Mean | $I_1$ | $I_2$ | $I_3$ | Mean | $I_1$ | $I_2$ | $I_3$ | Mean |
| MS/6-1947 | 48.0 | 38.3 | 29.7 | 38.7 | 51.1 | 41.2 | 32.1 | 41.5 | 16.2 | 17.4 | 18.9 | 17.5 |
| Kufri Bahar | 38.0 | 34.9 | 23.7 | 32.2 | 40.1 | 37.2 | 26.1 | 34.5 | 19.8 | 20.4 | 20.4 | 20.2 |
| Kufri Pukhraj | 43.2 | 36.7 | 24.9 | 34.9 | 45.3 | 39.2 | 26.6 | 37.0 | 16.7 | 18.0 | 18.8 | 17.8 |
| Mean | 43.0 | 36.6 | 26.1 | 35.2 | 45.5 | 39.2 | 28.3 | 37.7 | 17.6 | 18.6 | 19.4 | 18.5 |
| *Statistics* | *CD 0.05* | | | | *CD 0.05* | | | | *CD 0.05* | | | |
| Irrigation (I) | 1.61 | | | | 1.64 | | | | 0.72 | | | |
| Clone/variety (C) | 1.61 | | | | 1.64 | | | | 0.72 | | | |
| I × C | 2.78 | | | | 2.84 | | | | 1.25 | | | |

$I_1$, Normal irrigation; $I_2$, Mild water stress; $I_3$, Severe water stress.

reported difference in tuber dry matter content in water deficit treatments over control.

All the genotypes significantly differed in plant vigour observed at 75 days. Clone MS/6-1947 exhibited better mean plant vigour (5.83) over the control Kufri Bahar (5.11) and Kufri Pukhraj (5.05). Mean plant vigour declined with increase in intensity of drought in all the crop season and lowest plant vigour (4.72) was attained with severe drought treatment at 75 days. Interaction of irrigation and clones was non-significant. Plant wilting did not vary markedly among genotypes, but irrigation treatments influenced it at 75 days. MS/6-1947 recorded lowest wilting (2.75) followed by control Kufri Pukhraj (2.78) and Kufri Bahar (3.04). Reduction in soil moisture availability affected this physiological trait and severe drought treatment had significantly higher wilting (3.81) in comparison to normal irrigation (2.02). Drought tolerance index were used to screen and identify the drought tolerant genotypes. Deshmukh *et al*. (2004) reported that drought-resistant genotypes should have high drought tolerance index (DTI). In the present study, maximum DTI was found in MS/6-1947 (1.02 and 0.79) followed by Kufri Pukhraj (0.86 and 0.58) and Kufri Bahar (0.72 and 0.51) under mild and severe water deficit treatment respectively (Fig 1). Differences in potato genotypes for DTI indices due to water stress were earlier reported by several workers in different crops (Schafleitner *et al*. 2007, Parameshwarappa and Salimath 2008, Hassanpanah 2010, Jose and Awan 2008, Rawal *et al*. 2014).

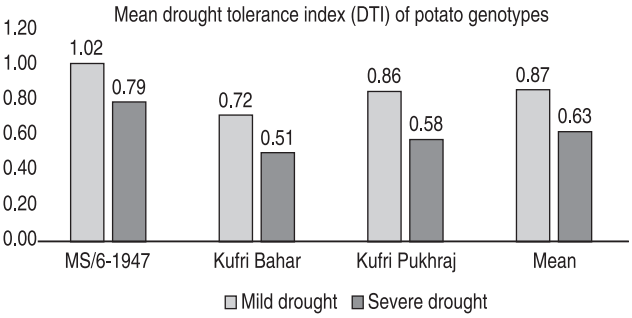


Fig 1 Drought tolerance index (DTI) in MS/06-1947 under different irrigation regimes (Pooled mean of 3 years: 2010-13; Based on total tuber yield t/ha) at Modipuram.

*Performance under water deficit conditions at Jodhpur*

Maximum and minimum temperatures during the potato growing season (2012-2015) ranged between 22.92-30.96°C and 8.41-14.37°C, respectively. Total mean rainfall of 11.06 mm was recorded on two occasions during the crop period. Though the day and night temperature calculated as per formula of Went (1957) reflected reduction of 2.59 to 4.72°C in maximum and augment of 2.59 to 4.72°C in minimum temperature. The night temperature plays an important role during tuberization and night temperature for optimum tuber formation are regarded in the range of 10-17ºC (Bodlaender 1963, Moorby and Milthorpe 1975). The temperature profile of Jodhpur revealed prevailing night temperature of 17.70°C during tuber initiation (25 days after planting) might have some detrimental effect on crop growth and tuberization initiation. During water deficit trial at Jodhpur, 1374 accumulated degree day were recorded.

The investigation revealed significant difference between genotypes and irrigation levels for tuber yield and tuber dry matter content (Table 3). MS/6-1947 out performed under normal irrigation and mild water stress conditions as compared to the best control Kufri Pukhraj and heat tolerant variety Kufri Surya as yield reduction was comparatively lower in MS/6-1947 under mild water stress and severe water stress conditions. Under normal irrigation, MS/6-1947 with marketable yield (35.2 t/ha) and total tuber yield of 36.8 t/ha showed yield enhancement over Kufri Pukhraj (11% and 3%) and Kufri Surya (74% and 63%). The results under sever water stress conditions showed improvement in yield in MS/6-1947 for marketable (27.8 t/ha, 13%) and total tuber yield (29.4 t/ha, 4%) remaining significantly high than the Kufri Pukhraj (24.6 and 28.3 t/ha). MS/6-1947 recorded markedly superior marketable (27.8 t/ha, 73% higher) and total tuber yield (29.4 t/ha, 62% higher) over heat tolerant variety Kufri Surya (16.1 and 18.1

Table 3 Mean tuber yield and tuber dry matter content of MS/06-1947 under different irrigation regimes (Pooled mean of 3 years: 2012-15) at Jodhpur

| Genotype | Tuber yield (t/ha) | | | | | | Tuber dry matter content (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Marketable | | | Total | | | | | |
| | $I_1$ | $I_2$ | Mean | $I_1$ | $I_2$ | Mean | $I_1$ | $I_2$ | Mean |
| MS/6-1947 | 35.2 | 27.8 | 31.5 | 36.8 | 29.4 | 33.1 | 16.4 | 18.7 | 17.6 |
| Kufri Pukhraj | 31.8 | 24.6 | 28.2 | 35.6 | 28.3 | 32.0 | 17.6 | 18.3 | 18.0 |
| Kufri Surya | 20.2 | 16.1 | 18.2 | 22.5 | 18.1 | 20.3 | 21.0 | 21.8 | 21.4 |
| Mean | 29.1 | 22.9 | 26.0 | 31.6 | 25.3 | 28.5 | 18.4 | 19.6 | 19.0 |
| *Statistics* | | $CD_{0.05}$ | | | $CD_{0.05}$ | | | $CD_{0.05}$ | |
| Irrigation (I) | | 1.56 | | | 1.37 | | | 0.49 | |
| Clone/variety (C) | | 1.91 | | | 1.68 | | | 0.60 | |
| I × C | | 2.71 | | | 2.38 | | | 0.85 | |

$I_1$, Normal irrigation; $I_2$, Mild water stress.

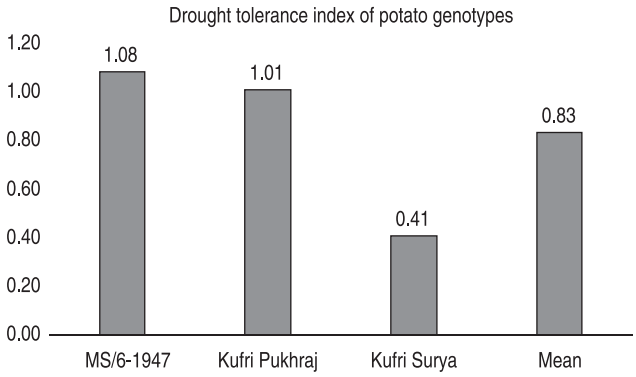


Fig 2 Drought tolerance index (DTI) in MS/06-1947 under mild irrigation regime (pooled mean of 3 years: 2012-15; Based on total tuber yield t/ha) at Jodhpur.

t/ha). Tuber matter content increased in all the genotypes. MS/6-1947 showed at par tuber dry matter content with Kufri Pukhraj under different water regimes. Kumar *et al.* (2007), Jose and Awan (2008) and Rawal *et al.* (2014) also reported difference in tuber dry matter content in water deficit treatments over control.

Plant vigour varied significantly among different genotypes at 75 days. MS/6-1947 recorded maximum mean plant vigour (7.62) at 75 days, which was markedly better over both the controls Kufri Surya (6.92) and Kufri Pukhraj (6.59). This parameter reduced with increased moisture stress as highest mean plant vigour (7.19) was observed with normal irrigation as compared to mild water stress (6.89) and interactions were not visible between irrigation and genotypes. Wilting varied distinctly among genotypes and with increase in water stress and MS/6-1947 had lowest wilting (2.70) than the control Kufri Pukhraj (2.92) and Kufri Surya (3.59) at 75 days. Reduction in soil moisture availability enhanced wilting drastically, however, interaction for both the factors was not distinct at 75 days. Drought tolerance index were used to screen and identify the drought tolerant genotypes. Deshmukh *et al*. (2004) reported that drought-resistant genotypes should have high drought tolerance index (DTI). In the present study, DTI values were maximum in MS/6-1947 (1.08) followed by Kufri Puhkraj (1.01) and Kufri Surya (0.41) severe water deficit treatment (Fig. 2). Differences in potato genotypes for DTI indices due to water stress were earlier reported by several workers in different crops (Schafleitner *et al*. 2007, Parameshwarappa and Salimath 2008, Hassanpanah 2010, Rawal *et al*. 2014).

The advanced stage hybrid MS/6-1947 produces 9 to 10 medium sized attractive white cream ovoid tubers with shallow eyes and cream flesh colour. The tubers of MS/6-1947 are easy to cook (15-20 min) and cooked/boiled potatoes are free from discolouration. It possesses pleasant flavour, mealy texture and is suitable for table potatoes.

The results indicate that the advanced stage hybrid MS/6-1947 can be a good choice for cereal based cropping systems, early-short duration crop and for achieving sustainable yields in non-traditional areas where water is a limiting factor for growing the crop like potato. This elite genetic stock can well be utilized in future breeding progarmmes targeting better marketable yields under heat and water stress conditions.

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