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Study of the influence of water stress on growth and development of crop plants

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ABSTRACT :
Potatoes are widely grown in India, but the greatest concentration by far occurs along the Indo-Gangetic Plain to the north east, where most potatoes are grown during the short winter days from October to March. Potato cultivation in the south is generally limited by an excessively hot climate. In India the states of Uttar Pradesh, West Bengal and Bihar accounts for more than 75% of total area under cultivation and about 80% of total potato production. Punjab state contributes roughly 7% in area and production. In higher altitude areas in north, a summer crop accounts for about 5% of total production. Regarding the southern peninsula, where approximately six percent of the total crop is grown on relatively high altitude plateaus, such as the Nilgiri and Palini hills of Tamil Nadu, under alternating rainfed and irrigated conditions through out the year.

Key words : potato, peninsula, cultivation.

INTRODUCTION:

Generally, there are two major cropping seasons in India. *Kharif*, during the south-west monsoon (June-July through September-October), when agricultural production takes place both in rainfed areas and irrigated conditions. *Rabi*, during the winter, when agricultural activities takes place only in the irrigated areas. India's climate is highly variable over the enormous range of the country, there are distinct seasons. A failure of the monsoons can occur due to climatic or geographical phenomena such as *El Nino* Southern Oscillation (ENSO), causing severe long term and extensive drought as happened several times from 1876 to 1902 and thereafter in the last century.

Depletion of land water resources and adverse effects of global climate change are becoming crucial for future agriculture. To fulfill the food requirement in this fast changing scenario for more than 100 billion peoples are the major challenges not only against Indian farmers but Agricultural Scientists also. Agricultural crops face several types of stresses including water stress due to scarcity of water for irrigation. Potato is one of the main vegetable crops in India. Potato is considered to be very drought sensitive and drought stress even occurs under irrigated potato production. Hence, yields are frequently constrained by drought in most of the environments. Water stress affects the development and the growth of shoots, roots and tubers. In order to minimize the yield losses due to water stress, it is desirable to use drought tolerant varieties, adopt improved agro technology which requires less water, identify the critical growth stages sensitive to water stress in potato cultivars so that drought can be avoided on these crucial stages of growth and development.

REVIEW OF LITERATURE

Khorshidi *et al.* (2007) applied the stress treatment after 50% flowering till the end of flowering. Stem dry weight was measured every other week and in the end of the growth period. Result showed that any stress might decrease the stem dry weight in relation to the control. Differences in stem dry weight was recovered in the stress levels. Stem number decreased in cultivars under mild stress was also recovered. Inspite of the decreasing yield, there was no difference in tuber number at the different stress levels. In Agria, the stem dry

weight in mid season was faster than the other cultivars. Agria showed the highest root dry weight and stem length. Draga showed an end-season recovery and its stem dry weight was greater than others; it had the highest main stem number in early-season but showed an acute decrease and its difference with others was non-significant at end-season.

Minhas and Bansal (2010) found maximum reduction in RWC under water stress imposed at stolon initiation. They experienced the minimum RWC (ranging from 69% to 74% in different cultivars) at this stage due to water stress. A negative correlation (r = -0.743) was noticed between RWC and percent reduction in tuber yield due to water stress at stolon initiation stage. No correlation existed between RWC and yield reduction due to drought at other stages of growth. Kumar and Minhas (1999) found reduction in RWC under water stress of Kufri Chandramukhi at tuber initiation (11.7%) and tuber development (12.5%).

Bansal and Nagarajan (2011) reported that leaf expansion is sensitive to even mild water stress. Leaf expansion was not monitored in the present experiment but the level of RWC in the leaves indicated that leaf area development must have been affected, particularly at stolon initiation which has minimum RWC and the proportion of younger leaves was more than mature leaves. Decrease in RWC of the leaf is often associated with a decline in photosynthesis rate. Moorby *et al.* (1975) found a greater effect of drought on young leaves than on older ones. Levy (1983) found that the values for water potential and osmotic potential were lower in Desiree than in Up-to-date in both non-stressed and water-stressed leaves. Plotting changes in osmotic potential against changes in water potential suggested tendency towards osmotic regulation in Desiree. In leaves that showed first signs of wilting, leaf water potentials lower than –8.0 and –9.0 bars were measured in Up-to-date and Desiree respectively.

Tourneux *et al.* (2012) studied six potato genotypes under three water regimes R_0 (well irrigated control), R_1 (Progressive drought after tuberisation and recovery period) R_2 (no recovery) they observed that under drought conditions cultivar Lucky exhibited a high stomatal resistance and cultivar Alpha showed the lowest stomatal resistance especially at the end of the R_2 treatment.

Kumar *et al* (2013) studied four potato varieties namely Kufri Pukhraj, Kufri Chipsona-1, Kufri Lauvkar (all indigenous) and Desiree (exotic) under water stress conditions. They found that reducing sugar content was significantly increased due to water stress in all the indigenous varieties and it ranged from 335.2 to 350.1 mg/100 g fresh weight as compared to well watered control (179.2 to 296 mg/100 g fresh weight).The exotic variety Desiree, however showed a decline in reducing content under water stress conditions.

RESULTS & DISCUSSION:

Data on mean values of treatments in Table 1 showed that shoot height increased with the age of plants from tuber initiation stage to tuber maturation stage. Well watered control (T_1) plot maintained tallest plants at all growth stages in both the years. Water stress treatments T_2 (water stress at tuber initiation stage), T_3 (water stress at tuber enlargement stage) and T_4 (water stress at tuber maturation stage) caused the significant reduction in shoot height in comparison to their respective control (T_1) in both the years. Under water stress conditions smallest plants were observed in T_2 (22.7 and 23.6 cm during 2011-2012 and 2012-2013 respectively), whereas highest plants were observed in T_4 (51.4 and 52.5 cm during 2011-2012 and 2012-2013 respectively).

Maximum percent reduction in shoot height (35% and 33% in respective years) in comparison with respective well irrigated control was recorded when water stress was imposed at tuber initiation stage (T_2) whereas minimum percent reduction in shoot height (15% and 14% in respective years) in comparison with respective control was recorded when water stress was imposed at tuber maturation (T_4) stage.

The table 1 showed that in T_2 (water stress at tuber initiation stage), Kufri Chipsona-1 produced tallest plants (25.7 and 25.9 cm during 2011-2012 and 2012-2013 respectively) whereas cultivar Desiree produced smallest

plants (20.3 and 21.5 cm during 2011-2012 and 2012-2013 respectively). As a result of water stress at this stage shoot height of cultivar Kufri Lauvkar was found most affected (37% and 38% reduction) while Kufri Pukhraj as least affected (31% and 27% reduction).

In T_3 (water stress at tuber enlargement stage) also Kufri Chipsona-1 recorded highest shoot height (59.3 and 60.1 cm during 2011-2012 and 2012-2013 respectively) whereas Desiree recorded lowest shoot height (42.1 and 42.2 cm during 2011-2012 and 2012-2013 respectively). Under water stress conditions at tuber enlargement stage (T_3) the shoot height of cultivar Kufri Pukhraj was found most affected by water stress (30% and 31% reduction) in comparison with respective control.

Similarly in T_4 (water stress at tuber maturation stage) also Kufri Chipsona-1 recorded tallest plants (57.1 and 58.1 cm during 2011-2012 and 2012-2013 respectively) and Desiree recorded shortest plants (45.1 and 46.2 cm during 2011-2012 and 2012-2013 respectively) under water stress. In T_4 the cultivar Desiree was found most affected cultivar (20% and 19% reduction) whereas Kufri Chipsona-1 was found least affected cultivar (11% reduction in both the years) in comparison with respective well irrigated control.

The interaction between cultivar and treatments was found significant except when water stress was imposed at tuber initiation stage.

In general with the age of crop, root depth increased gradually from tuber initiation stage to tuber enlargement stage and then declined. Water stress treatments T_2 (water stress at tuber initiation stage), T_3 (water stress at tuber enlargement stage) and T_4 (water stress at tuber maturation stage) caused the significant reduction in root length in comparison with well watered control (T_1) in both the years. Mean values of treatments showed that well watered control plants have highest root depth at all growth stages in both the years. Under water stress conditions maximum root depth (17.2 and 17.3 cm during 2011-2012 and 2012-2013 respectively) was recorded in T_3 (water stress at tuber enlargement stage) while minimum root depth (9.9 and 10.1 cm during 2011-2012 and 2012-2013 respectively) was recorded in T_4 (water stress at tuber maturation stage). The trend in reduction in root depth showed that water stress during tuber maturity (T_4) caused maximum percent reduction (38% and 37% in respective years) in root depth whereas water stress at tuber initiation stage (T_2) caused minimum percent reduction (13% and 14% in respective years) in comparison with respective control.

Table 1.Effect of water stress on shoot height (cm/plant) at various growth stages of potato cultivars

Treatment*	**2011-2012**			**2012-2013**		
	Growth stage**			**Growth stage**		
	TI	TE	TM	TI	TE	TM
Kufri Chipsona-1						
T_1	38.8	62.4	64.1	37.5	63.1	65.1
T_2	25.7 (-34%)***	53.5	53.9	25.9 (-31%)	54.0	54.1
T_3	36.0	59.3 (-5%)	52.2	37.1	60.1 (-5%)	52.2
T_4	36.0	61.5	57.1 (-11%)	36.9	62.0	58.1 (-11%)
Mean	**33.4**	**59.2**	**56.8**	**34.4**	**59.8**	**57.4**
Kufri Pukhraj						
T_1	32.9	60.3	61.4	34.1	61.4	62.5

T_2	22.8 (-31%)	45.0	52.3	24.8 (-27%)	44.8	53.3
T_3	33.0	42.0 (-30%)	45.2	33.9	42.4 (-31%)	45.7
T_4	32.9	61.0	52.9 (-14%)	34.0	62.0	53.8 (-14%)
Mean	**30.4**	**52.1**	**52.9**	**31.7**	**52.6**	**53.9**
Kufri Lauvkar						
T_1	34.8	58.2	59.6	36.1	58.6	60.1
T_2	22.0 (-37%)	41.6	45.5	22.4 (-38%)	42.1	46.2
T_3	34.8	49.5 (-15%)	50.0	36.0	50.5 (-14%)	51.2
T_4	34.8	58.4	50.3 (-16%)	35.8	59.4	52.0 (-14%)
Mean	**31.6**	**51.9**	**51.3**	**32.6**	**52.7**	**52.4**
Desiree						
T_1	32.4	46.6	56.5	33.0	47.6	57.3
T_2	20.3 (-37%)	34.1	37.0	21.5 (-35%)	34.1	37.1
T_3	33.0	42.1 (-10%)	47.1	32.9	42.2 (-11%)	47.3
T_4	32.8	47.0	45.1 (-20%)	33.0	48.3	46.2 (-19%)
Mean	**29.7**	**42.4**	**46.4**	**30.1**	**43.0**	**47.0**
Mean Values of Treatments						
T_1	34.8	56.9	60.4	35.2	57.7	61.3
T_2	22.7 (-35%)	43.6	47.2	23.6 (-33%)	43.8	47.7
T_3	34.2	48.3 (-15%)	50.9	35.0	48.8 (-15%)	49.1
T_4	34.4	57.0	51.4 (-15%)	34.9	57.9	52.5 (-14%)
CD at 5%						
Cultivar(C)	1.3	2.1	2.1	1.3	1.2	2.2
Treatment (T)	1.0	1.6	1.6	1.0	1.1	1.8
C × T	NS	3.3	3.2	NS	2.2	3.5

***Treatments:** T_1 = Control (well watered), T_2 = water stress at tuber initiation,T_3 = water stress at tuber enlargement and T_4 = water stress at tuber maturation stage

****Growth stages:** TI = Tuber initiation, TE =Tuber enlargement and TM = Tuber maturation

***** Figures in parenthesis are percent (%)** change in shoot height due to water stress treatment T_2, T_3 and T_4 as compared with respective control

CONCLUSION

It can be concluded from the paper, that tuber initiation stage of potato crop is the most sensitive growth stage for water stress followed by tuber enlargement stage. Among the cultivars studied, cultivar Kufri Pukhraj has shown maximum resilience against water stress in different morphological, physiological and biochemical traits. It appears that Kufri Pukhraj adapted better than other cultivars in well watered control as well as water stress conditions. Moreover, tuber defects were also comparatively minimum in this cultivar.

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