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CONSEQUENCE OF WATER STRESS ON YIELD AND QUALITY OF POTATO TUBERS

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ABSTRACT:
The aim of effective and efficient watering of a growing crop is to replenish depleted soil moisture at a given time to avoid physiological water stress in the growing plants. Furrow irrigation method is a commonly used for potato (Solanum tuberosum L.) irrigation in Sudan, due to cost-effectiveness and low maintenance requirements of the method. Generally potato is grown in the winter season in the eastern, northern and central regions of Sudan through utilization of furrow irrigation. In recent years, the center pivot irrigation is used in the River Nile State. Globally, potatoes are grown under irrigation in arid and semi-arid regions. Water requirements of the potato plant has been the subject of many research works. It is given more attention as one of the key factors affecting potato yield.

Key words*:* Solanum tuberosum L., potatoes

INTRODUCTION:

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.

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 rain fed 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:

The potato is known to be very sensitive to the shortage of water (Van Loon, 1981 and Vayda, 1994). Several experiments carried out on water supply and yield under field conditions (Singh, 1969; Harris, 1978). It has been suggested that for maximal yields soil moisture should not be allowed to drop below approximately 50% of crop available water during the tuber bulking period. But there are also reports mentioning 25 or 75% instead of 50%. As regards the optimal soil water potential for maximum yield reports vary between 0.2 and 0.6 bars in the densely rooted soil layer. Potato yield also depends upon the timing of water stress within the growing period (Spitters and Schapendonk, 1990) and upon climatic and soil conditions. In a study by Deblonde *et al.* (1999) the effect of early drought and late drought were compared with a control, the relation between speed of maturation, timing of water shortage and effect on tuber yield was not as marked as expected. However later cultivars were shown to tolerate water shortage occurring in the early part of season. According to Jefferies and MacKerron (1987) an increase in tuber dry matter content has also been found to be an important factor influencing tuber yield variations in response to drought stress.

Lahlou *et al.* (2003) observed that the reduction by drought of fresh tuber yields were 11% for Desiree, 15% for Nicola, 18% for Monalisa and 44% for Remarka, in comparison with their respective controls. They also showed that final dry weight basis yield of tubers was affected in the same manner as fresh weight basis yield. In the field, drought decreased dry weight of tubers by 11, 13, 15 and 38% in Desiree, Nicola, Monalisa and Remarka respectively. Drought stress increased dry matter concentration in tuber for Remarka the increase was 10% in the field and 8% in green house. Desiree was not affected in field, but its dry matter concentration (DMC) increased by 11% under drought in the green house. Nicola and Monalisa tested in the field had an average increase of 2.5%.

Epstein and Grant (1973) determined leaf diffusion resistance under conditions of water stress for cv. Russet Burbank and Katahdin. Stomatal diffusion resistances of the Russet Burbank plants were two to three times greater than those for Katahdin. Levy (1983) also indicated that cultivars with differing values of stomatal conductance produce similar tuber yields under stress.

Genotypic differences in drought tolerance have been observed by Harris (1978) and Levy (1983). Drought adaptation of plants relies, mainly on four groups of mechanisms: escape, avoidance, tolerance, and recovery with each mechanic implying specific processes (Levitt, 1972). Many physiological characters of the potato plant (such as stomatal resistance, photosynthesis, leaf water content and leaf water potential) and morphological or agronomic characters (such as leaf area index, leaf senescence, canopy cover, dry matter production, partitioning of assimilates into tubers and tuber yield components) are affected by lack of water and could be used as indicators of the effects of drought on potato yields (Tourneux, et al., 2003).

Ekanayake et al. (1992) studied stomatal response of some cultivated and wild tuber bearing potatoes in warm tropics as influenced by water deficits, they grown 14 cultivated potato genotypes and 3 tuber bearing wild Solanum species in green houses or in the field in Peru either sufficiently or water stressed, they observed that all genotypes differed in leaf resistance and all genotypes had higher stressed. Genetic differences in stomatal behaviour of tuber bearing Solanum species were confirmed. Abaxaial stomatal resistance of water stressed plants of the species ranged between 1.74 and 13.8 s.cm-1. Stomatal resistance was increased by water stress about 3 fold in Solanum chacoense, 4-fold in Solanum tuberosum, and 5-fold in Solanum jugasense and Solanum raphanifolium.

RESULTS:

Table-1

Effect of water stress on non-marketable, marketable and total number of tubers (000/ha) of potato cultivars

Treatment*	2009-10			2011-12		
	Non-marketable tubers	Marketable tubers	Total No. of tubers	Non-marketable tubers	Marketable tubers	Total No. of tubers
Kufri Chipsona-1						
T_1	287	290	577	300	305	605
T_2	307 (+7%)**	250 (-14%)	557 (-4%)	325 (+8%)	260 (-15%)	585 (-3%)
T_3	304 (+6%)	259 (-11%)	563 (-2%)	320 (+7%)	275 (-10%)	595 (-2%)
T_4	290 (+1%)	278 (-4%)	568 (-2%)	305 (+2%)	295 (-3%)	600 (-1%)
Mean	297	269	566	313	284	596
Kufri Pukhraj						
T_1	312	278	590	325	298	623
T_2	375 (+20%)	190 (-32%)	565 (-4%)	392 (+21%)	200 (-33%)	592 (-5%)
T_3	363 (+16%)	210 (-25%)	573 (-3%)	385 (+19%)	215 (-28%)	600 (-4%)
T_4	335 (+7%)	245 (-12%)	580 (-2%)	345 (+6%)	270 (-9%)	615 (-1%)
Mean	346	231	577	362	246	608
Kufri Lauvkar						
T_1	256	163	419	270	180	450
T_2	299 (+17%)	100 (-39%)	399 (-5%)	315 (+17%)	105 (-42%)	420 (-7%)
T_3	288 (+13%)	116 (-29%)	404 (-4%)	302 (+12%)	128 (-29%)	430 (-5%)
T_4	271 (+6%)	138 (-15%)	409 (-2%)	280 (+4%)	160 (-11%)	440 (-2%)
Mean	279	129	408	292	143	435
Desiree						
T_1	281	220	501	298	258	556
T_2	306 (+9%)	160 (-27%)	466 (-7%)	315 (+6%)	190 (-26%)	505 (-9%)
T_3	293 (+4%)	182 (-17%)	475 (-5%)	308 (+3%)	205 (-21%)	513 (-8%)
T_4	290 (+3%)	200 (-9%)	490 (-2%)	302 (+1%)	230 (-11%)	532 (-4%)
Mean	293	191	483	306	221	527
Mean Values of Treatments						
T_1	284	238	522	298	260	559
T_2	322 (+13%)	175 (-27%)	497 (-5%)	337 (+13%)	189 (-27%)	526 (-6%)
T_3	312 (+10%)	192 (-19%)	504 (-4%)	329 (+10%)	206 (-21%)	535 (-4%)
T_4	297 (+6%)	215 (-10%)	512 (-2%)	308 (+3%)	239 (-8%)	547 (-2%)
CD at 5%						
Cultivar(C)	2.3	3.6	2.9	2.6	3.6	2.6
Treatment (T)	2.3	3.6	2.9	2.6	3.6	2.6
C × T	4.7	7.1	5.7	5.3	7.1	5.1

*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

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

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