*Plant Archives* Vol. 17 No. 1, 2017 pp. 623-626 ***ISSN 0972-5210***

# EFFECT OF WATER STRESS ON HAULM YIELD, TOTAL BIOMASS AND HARVEST INDEX OF POTATO CULTIVARS

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## Abstract

Four potato varieties (*i.e.* Kufri Chipsona-1, Kufri Pukhraj, Kufri Lauvkar and Desiree) were investigated under water stress conditions with respect to three growth stages. The reduced photosynthetic activity of stressed plants caused a reduction in total biomass. Maximum percent reduction in total biomass production was recorded when water stress was imposed at tuber initiation stage ($\mathbf{T_2}$) while minimum percent reduction when water stress was imposed at tuber maturation stage ($\mathbf{T_4}$) as compared with well irrigated control. Under water stress conditions, Kufri Pukhraj maintained total biomass higher than other cultivars. At harvest, the haulm yield was found to be reduced due to water stress at tuber initiation stage and tuber enlargement stage. Kufri Chipsona-1 recorded highest haulm yield followed by Kufri Pukhraj.

***Key words :*** Harvest index, haulm yield, potato, total biomass, tuber growth stages, water stress.

## Introduction

Potato (*Solanum tuberosum* L.) is one of the most important food crops after wheat, maize and rice, contributing to food and nutritional security in the world (Khorshidi *et al.,* 2007). Increasing temperature in certain seasons around the world is the result of global warming leading to increased rates of water evaporation and thus surface drying, thereby increasing intensity and duration of drought. (Kumar *et al*., 2005). Drought is increasingly an important factor affecting crop production worldwide, and it also reduces tuber yield of potato. Among the environmental factors soil moisture is a major limiting factor in the production and growth of potatoes (Van-der-Zaag and Doornbos, 1987). Harvest Index (HI) is a key partitioning index that shows the extent of remobilization of photosynthates to tubers. Studies recommend that maintaining a high HI is the best strategy for improving crop yields under drought stress conditions (Minhas and Bansal, 1991; Kumar and Minhas, 1999).

The evidence on the effect of drought on partitioning of assimilate to tubers appears to be conflicting. Jefferies (1993) in a comparison of seven potato genotypes found that drought significantly increased harvest index in one cultivar and decreased it in another. These differences in response may reflect genotypic differences in development and differences in the timing and severity of the water stress imposed. Timing of water stress relative to tuber initiation may be critical in determining patterns of assimilate partitioning. Water stress early in the season reduces the number of stolons and tubers initiated (MacKerron and Jefferies, 1986; Haverkort *et al*., 1990). Thus, severe and prolonged stress from early in the season may constrain tuber initiation causing assimilate to be partitioned to other organs. However, if water stress occurs after tubers have been initiated, then partitioning to tubers is promoted and maturity is advanced. Further work is required to understand the partitioning in relation to the timing and severity of water stress in potato tubers. Considering these facts, this study was carried out to analyse effects of water stress on haulm yield, total biomass and HI in four potato varieties at different growth stages.

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## Materials and Methods

The field experiments were conducted at Research Farm of CPRI Campus, Modipuram, Meerut (U.P.), India during *rabi* season of 2005-06 and 2006-07. Forty eight plots were used in a split plot design for accommodating 4 treatments. Field trials were conducted in split plots with three replicates employing the 4 varieties (*i.e.* Kufri Chipsona-1, Kufri Pukhraj, Kufri Lauvkar and Desiree) having following treatments:

**$T_1$** : Control (well watered plants)

**$T_2$** : Water stress at - tuber initiation stage

**$T_3$** : Water stress at - tuber enlargement stage

**$T_4$** : Water stress at - tuber maturation stage

**$T_1$** control (well watered) plots were irrigated at 6 DAP (days after planting), 27 DAP, 42 DAP, 63 DAP and 80 DAP during the year 2005-06 and at 8 DAP, 25 DAP, 44 DAP, 67 DAP and 83 DAP during the year 2006-07. The water stress was imposed by withholding water in **$T_2$**, **$T_3$** and **$T_4$** treatments at different growth stages. The growth stage was identified and confirmed by uprooting the plants and by examining the stage of tuber development. Experimental plots were dehaulmed at 90 DAP and harvesting was done 10-15 days after of dehaulming so that tuber skin is matured.

After haulm cutting, the haulms were weighed from all plots and data were recorded. Estimation of total biomass was calculated by adding haulm weight and total tuber yield. Haulms and total tubers were weighed on 30 kg electronic, portable balance (Avery, A 611W digital scale).

The harvest index was calculated according the following formula:

$$\text{Harvest index (\%)} = \frac{\text{Tuber yield}}{\text{Total biological yield}} \times 100$$

**Statistical analysis**

Data recorded during the course of study were subjected to statistical analysis by applying the technique of analysis of variance (ANOVA) prescribed for the split plot design (Gomez, 1984) to the significance of the overall difference among treatments by the 'F' test. The critical difference at 5% level of probability was worked out to compare treatment means where "F" test was significant.

## Results

At harvest, the haulm yield was found to be reduced due to water stress at tuber initiation stage and tuber enlargement stage. Kufri Chipsona-1 recorded highest haulm yield (133 q/ha and 112q/ha in control and water stress at tuber initiation stage respectively, during 2005-06).

The mean values of treatments showed that well watered control (**$T_1$**) has maximum total biomass and water stress caused significant reduction in total biomass against well watered control. Lowest total biomass was recorded in **$T_2$** (340 and 359 q/ha during 2005-06 and 2006-07 respectively) whereas highest in **$T_4$** (390 and 398 q/ha during 2005-06 and 2006-07 respectively) under water stress conditions. Maximum percent reduction in total biomass production (14% in both the years) was recorded when water stress was imposed at tuber initiation stage (**$T_2$**) while minimum percent reduction (1% and 5% in respective years) when water stress was imposed at tuber maturation stage (**$T_4$**) as compared with well irrigated control.

Data in table 1 clearly showed that total biomass was reduced due to water stress treatments in all cultivars during both the years. Kufri Pukhraj recorded maximum total biomass (403 and 462 q/ha during 2005-06 and 2006-07 respectively) whereas Desiree recorded minimum total biomass (261 and 263 q/ha during 2005-06 and 2006-07 respectively) under water stress at tuber initiation stage (**$T_2$**). Under water stress treatment **$T_3$** (water stress at tuber enlargement stage) Kufri Pukhraj recorded maximum total biomass (408 and 481 q/ha during 2005-06 and 2006-07 respectively) while Desiree (279 and 283 q/ha during 2005-06 and 2006-07, respectively) recorded minimum total biomass. When water stress was imposed at tuber maturation stage (**$T_4$**) Kufri Pukhraj recorded maximum total biomass production (487 and 513 q/ha during 2005-06 and 2006-07 respectively) while Desiree recorded minimum total biomass (283 and 288 q/ha during 2005-06 and 2006-07, respectively).

The mean values of treatments showed non-significant differences in different treatments regarding the parameter of harvest index.

## Discussion

Agricultural productivity is severely reduced by various biotic and abiotic stresses (Boyer, 1982). In present study, total biomass production was reduced by water stress in comparison with well irrigated control (table 1). Same trend was found with respect to haulm yields. Reduction in total biomass under water stress can be ascribed by increase in stomatal resistance and decrease in leaf area and net photosynthetic rate due to water stress. The extent to which crop productivity is affected depends largely on the stage of development at which the plant encountered stress (Salter and Goode, 1967).

**Table 1 :** Effect of water stress on haulm yield (q/ha), total biomass (q/ha) and harvest index (%) of potato cultivars.

| Treatment* | 2005-06 | | | 2006-07 | | |
|---|---|---|---|---|---|---|
| | Haulm yield | Total biomass | Harvest index | Haulm yield | Total biomass | Harvest index |
| **Kufri Chipsona-1** | | | | | | |
| $T_1$ | 133 | 359 | 63 | 149 | 437 | 66 |
| $T_2$ | 112 (-16%)*** | 325 (-9%) | 65 (+3%) | 114 (-23%) | 377 (-14%) | 70 (+6%) |
| $T_3$ | 100 (-25%) | 311 (-13%) | 74 (+17%) | 104 (-30%) | 372 (-15%) | 72 (+9%) |
| $T_4$ | 132 (-1%) | 370 (+3%) | 64 (+1%) | 147 (-1%) | 418 (-4%) | 65 (-1%) |
| Mean | **119** | **341** | **65** | **129** | **401** | **68** |
| **Kufri Pu--khraj** | | | | | | |
| $T_1$ | 129 | 484 | 73 | 134 | 502 | 73 |
| $T_2$ | 100 (-22%) | 403 (-17%) | 75 (+3%) | 101 (-25%) | 462 (-8%) | 78 (+7%) |
| $T_3$ | 92 (-29%) | 408 (-16%) | 79 (+8%) | 95 (-29%) | 481 (-4%) | 80 (-10%) |
| $T_4$ | 128 (-1%) | 487 (+1%) | 74 (+1%) | 136 (+1%) | 513 (-2%) | 73 (0%) |
| Mean | **112** | **445** | **75** | **117** | **489** | **76** |
| **Kufri Lauvkar** | | | | | | |
| $T_1$ | 97 | 426 | 77 | 98 | 434 | 77 |
| $T_2$ | 83 (-14%) | 372 (-13%) | 70 (-9%) | 86 (-12%) | 333 (-23%) | 74 (-4%) |
| $T_3$ | 80 (-18%) | 370 (-13%) | 78 (+1%) | 81 (-17%) | 331 (-24%) | 76 (-1%) |
| $T_4$ | 95 (-2%) | 419 (-2%) | 77 (0%) | 96 (-2%) | 371 (-15%) | 74 (-4%) |
| Mean | **89** | **397** | **78** | **90** | **367** | **75** |
| **Desiree** | | | | | | |
| $T_1$ | 62 | 311 | 80 | 64 | 299 | 79 |
| $T_2$ | 63 (+2%) | 261 (-16%) | 76 (-5%) | 65 (+1%) | 263 (-12%) | 75 (-5%) |
| $T_3$ | 61 (-2%) | 279 (-10%) | 78 (-3%) | 62 (-3%) | 283 (-5%) | 78 (-1%) |
| $T_4$ | 63 (+2%) | 283 (-9%) | 78 (-3%) | 64 (0%) | 288 (-4%) | 78 (-1%) |
| Mean | **62** | **284** | **78** | **64** | **283** | **77** |
| **Mean Values of Treatments** | | | | | | |
| $T_1$ | 105 | 395 | 73 | 111 | 418 | 74 |
| $T_2$ | 90 (-14%) | 340 (-14%) | 71 (-3%) | 92 (-17%) | 359 (-14%) | 74 (0%) |
| $T_3$ | 83 (-21%) | 342 (-13%) | 77 (+5%) | 86 (-23%) | 367 (-12%) | 77 (+4%) |
| $T_4$ | 104 (-1%) | 390 (-1%) | 73 (0%) | 80 (-19%) | 398 (-5%) | 73 (-1%) |
| **CD at 5%** | | | | | | |
| Cultivar(C) | 3.97 | 16.25 | 3.15 | 3.56 | 13.65 | 2.64 |
| Treatment (T) | 3.22 | 12.05 | NS | 2.89 | 10.36 | NS |
| C × T | 6.44 | 24.11 | NS | 5.77 | 20.62 | 3.88 |

***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.

In our study, tuber initiation stage of potato plant was found most sensitive and tuber maturation stage least sensitive for reduction in total biomass production under water stress. Minhas and Bansal (1991) also found tuber initiation stage as the most sensitive stage for water stress treatments. Under water stress conditions the cultivar Kufri Pukhraj maintained total biomass higher than other cultivars, due to its comparatively higher leaf area, photosynthetic rate, and chlorophyll content.

## References

Boyer, J. S. (1982). Plant productivity and environment. *Science*, **218** : 443-448.

Gomez, K. A. and A. A. Gomez (1984). *Statistical Procedures for Agricultural Research*. New York: John Wiley and Sons.

Haverkort, A. J., M. Van-De-Waat and K. B. A. Bodlaender (1990). The effect of early drought stress on numbers of tubers and stolons of potato in controlled and field conditions. *Potato Res.*, **33** : 89-96.

Jefferies, R. A. (1993a). Cultivar response to water stress in potato: effects of shoot and root. *New Phytologist*, **123** : 491-498.

Jefferies, R. A. and D. K. L. MacKerron (1993). Responses of potato genotypes to drought. II. Leaf area index, growth and yield. *Annals of Applied Biology*, **122** : 105-112.

Khorshidi, M. B., D. Benam and Hassanpanah (2007). Evaluation of different potato cultivars at different irrigation periods and different drought stages. *ISHS Acta Horticulturae*-729 (http://www.actahort.org).

Kumar, D. and J. S. Minhas (1999). Effect of water stress on photosynthesis, productivity and water status in Potato. *Indian Potato Associ*., **26(1 & 2)** : 7-10.

Kumar, S., D. Kumar, P. Kumar and J. S. Minhas (2005). The effect of repeated water stress on tuber quality and reducing sugar content in selected potato (*Solanum tuberosum* L) varieties. Abstract in: *National seminar on plant physiology (crop productivity and quality improvement through physiological interventions) Navsari Agaricultural University, Navsari* III-P-22.

MacKerron, D. K. L. and R. A. Jefferies (1986). The influence of early soil moisture stress on tuber numbers in potato. *Potato Res*., **29** : 299-321.

Minhas, J. S. and K. C. Bansal (1991). Tuber yield in relation to water stress at different stages of growth in potato (*Solanum tuberonum* L.). *J. Indian Potato Associ*., **18** : 1-8.

Salter, P. J. and J. E. Goode (1967). Crop responses to water at different stages of growth. *Research Reviews of the Commonwealth Bureau of Horticulture*, *East Malling*, **2** :93-97.

Van-der-Zaag, D. E. and J. H. Doornbos (1987). An attempt to explain differences in the yielding ability of potato cultivars based on differences in cumulative light interception, utilization efficiency of foliage and harvest index. *Potato Res*., **30** : 551-568.