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RESEARCH PAPER

Effect of relative water content and water use efficiency of *Lactuca sativa* under different methods of growing

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Abstract : The present study entitled "Effect of relative water content and water use efficiency of *Lactuca sativa* under different methods of growing"was conducted to demonstrate water saving techniques and their role in plant growth and sustainable development that given a new dimension to modern agriculture. For experiment, two varities of lettuce was used i.e., *Romaine* and *Grand rapid.* The experiment was carried out in hydroponics having growing media and also in pots with equal amount of Farm Yard Manure at the experimental house of the Division of Plant Physiology, SKUAST-J. Growing media was therefore, applied in different ratio i.e., coco peat (100 %), Coco peat + Vermicompost (1:1), coco peat + perlite (1:1), coco peat + vermiculite (1:1), coco peat + perlite + vermiculite (1:1:1), coco peat + perlite + vermiculite + vermicompost (1:1:1:1) as well as with conventional method (soil + Manure). The performance of both varieties under hydroponic treatments was compared with the plants grown by conventional method. The experimental results revealed that among both the varities, treatment T_5 performed better as compared to other treatments and should be recommended to other hydroponic growers and farmers in future.

Key Words : Dimensions, Agriculture, Manure, Treatments, Performance, Varities

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INTRODUCTION

Lactuca sativa L. which is commonly known as lettuce, is a part of the family Asteraceae (Compositae), a fruitful and different gather of plants with a worldwide dissemination (Funk et al., 2005). Many medieval authors defined *Lactuca sativa* and its makes use of specifically as a medicinal herb. Bennett et al. (2001) defined three simple present day lettuces consisting of head lettuce, loose-leaf lettuce, and romaine or cos lettuce. Lettuce is produced substantially with inside the United States each with inside the area and below greenhouse systems both in soil, soilless media, or hydroponic systems. The lettuce grown in the United States on over 130,000 hectares was valued at $2 billion, with the vast majority of production taking place in California and Arizona and therefore dispersed across the country (Boriss et al., 2005). The worldwide generation of lettuce in 2013 totalled nearly 25 million tons, with China, the Joined

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together States, and India creating 13.5, 3.6, and 1.1 million tons, separately (FAO, 2014). Bradley *et al.* (2000) detailed that noteworthy utilize of hydroponic innovation comes about in decreased arrive necessity for crops by 75% or more and moderates 90% water moreover leftover impact of chemicals to the environment was insignificant. Steidle *et al.* (2009) detailed that programmed control framework given water system and supplements without influencing edit generation and customary control framework. Ponders conducted by (Mohammed, 2018) found that the supplement film strategy (NFT) is one of the foremost common strategy in hydroponics, which comprises of a circulating framework that supplies water containing supplements to plant roots. NFT hydroponic framework is to a great extent utilized in Brazil, primarily for lettuce crops (Luz, 2017). The water containing supplement arrangement streams through developing channels where the plant roots are to inundate and supply oxygen and supplements to plants (Martins, 2009). Yeager *et al.* (2007) detailed that number of substrates are utilized in hydroponics development like saw clean, coconut fiber, desert spring 3d shapes, sphagnum peat greenery, rice bodies, polyurethane, develop pieces, clay bricks, magma rocks, LECA etc. Substrate ought to free from microorganism destructive to man or plants ought to be eco-friendly, which can anticipate root spoil infection with unbiased pH and store of supplement in root zone.

Every year, 87 % of the freshwater is utilized around the world for agrarian generation (Postel, 2001). In common, it is troublesome to rationalize the dependable water supply since of regular and geological varieties (Choi *et al.,* 2011).Water lack encompasses a profound impact on biological and agricultural systems and could be a restricting calculate within the beginning stage of plant development and foundation (Rochefort *et al.,* 1992). Hydroponic systems are commonly planned as open (*i.e.,* once the supplement arrangement is conveyed to the plant roots, it isn't reused) or closed (*i.e.*, overflow arrangement is recuperated, recharged, and reused) frameworks. Hoekstra *et al.* (2001) discovered that a lack of water causes stomatal closure and decreased transpiration rates, a decrease in water potential, a decrease in photosynthetic activities, an accumulation of consistent solutes, the union of unused proteins, and an increase in the level of reactive oxygen species (ROS) rummaging compounds like ascorbate, glutathione, and alpha-tocopherol. Subsequently, combating water push is vital for the change of trim assortments. Tripathi *et al.* (2015) watched changes in physiological reactions when hydroponics framework utilized. Got dried out plants were still able to recuperate and re-grow when re-placed into the hydroponics arrangement, appearing that plants were still practical indeed when subjected to extraordinary drying out (5 h). Harb *et al.* (2010) taken note in their try thatin roots, an 11% diminish in add up to water substance (%TWC) from 3 to 5 h of lack of hydration was watched whereas a 10% diminish in takes off %TWC from 2 to 5 h was watched. In expansion to higher yields and water effectiveness, when practiced in a controlled environment, hydroponic frameworks can be planned to back persistent generation all through the year (Brechner *et al.,* 2014). Most hydroponic frameworks will utilize water more proficiently than customary cultivating. Zucchini plants developed in a closed soilless framework (cocofibre, perlite and pumice culture) displayed higher water utilize effectiveness compared with those developed in soil (Rouphael *et al.,* 2004). The water utilize proficiency (*i.e.* the proportion of natural product dry weight per unit of connected water) was essentially higher by 76% in plants developed in soilless medicines than in soil.

MATERIAL AND METHODS

The present study entitled "Effect of relative water content and water use efficiency of *Lactuca sativa* under different method of growing." was carried out in the Department of Plant Physiology, Faculty of Basic Sciences, Sher-e- Kashmir University of Agricultural Science & Technology of Jammu, Main Campus Chatha, during 2019-2020. Two varities of lettuce - *Romaine* and *Grand rapid* were raised. Seeds of both varieties were collected from PAU, Ludhiana, Punjab and HPKV, Palampur, Himachal Pradesh. The chapter is split into following sections:

Description of study area

Experimental site and location:

The experiment was conducted from October 2019 to March, 2020 in the Division of Plant Physiology, Faculty of Basic Sciences, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Main Campus Chatha, Jammu-180009, J&K. Geographically the experimental site is located at 320 - 40' N latitude and 740 - 58' E longitude with an altitude of 332 m above mean sea level in the Shiwalik foot hills of North-Western

Himalayas.

MATERIAL AND METHODS

Hydroponic structure:

In hydroponic system nutrient film technique (NFT) was used, which is carried out in a structure made with fine and strong PVC pipes. Eighteen PVC pipes having ten feet long, six feet wide and 8 feet height with 4 inches were used to create hydroponics system of 180 pot holes arranged in three tires using iron angles or frame. The hydroponic pots were fitted in the holes. The whole structure was covered with polythene sheet to reduce the atmospheric temperature.

Substrates:

The substrates used in research work.
– Coco peat
– Perlite
– Vermiculite
– Vermicompost.

Nutrients supplement :

The Green loop Leafy-200 hydroponic nutrient was used in the experiment due to its versatile nature, mainly composed of both macro and micro nutrients. It was generally used for herbs, salad and all kind of leafy vegetables. The nutrient was comprised of two sealed bottles A and B, each contained separate solid nutrient.

Composition of pure hydroponic nutrient:

Macronutrients :
Calcium 23%
Nitrogen 23%
Phosphorous 7%
Potassium 32%
Magnesium 5.3%
Sulphur 9%
Micronutrients
(Boron, Chlorine, Manganese, Zinc, Copper, Sodium, Molybdenum, Iron, Chlorine) 0.7%.

Varieties:

The two common varieties of lettuce were used for the study:

V_1 - *Romaine* and V_2 - *Grand rapid.*

Lay out of experiment :

The experiment was laid out using Factorial Complete Randomised Block Design. There were total six treatments including conventional method and three replications.

Date of seed sowing:

Seeds of both varieties were sown in seedling trays inside the laboratory of Plant Physiology on 10th of October, 2019 and after two weeks, seedlings of both varities came out.

Date of transplanting in hydroponics: 29th of November, 2019.

Procedure of transplanting in hydroponics:

Experiment was executed on the basis of nutrient film technique:

In this technique, seedlings of both varities were first transplanted into hydroponic pots filled with separate combination of substrates and then pots were placed in the hydroponic structure containing PVC pipes. There were total 18 pipes, the nine pipes from the ground floor were assigned to *Romaine* lettuce and remained nine pipes were assigned to *Grand rapid* with different concentrations of growing media. The hydroponic nutrient solution was added into the tank that continuously cycled through the pipes for 40 minutes.

Conventional method:

For comparison study, conventional method was used in which seeds of both varieties were sown in pots. No treatment was given to pots. For the preparation of pots, soil and manure were used.

Treatments :	**Different growing media were used in different concentration**	
Treatment	Media / Substrates	Ratio
T_0	Coco peat	(100%)
T_1	Coco peat + Vermicompost	(1:1)
T_2	Coco peat + Perlite	(1:1)
T_3	Coco peat + Vermiculite	(1:1)
T_4	Coco peat + Perlite + Vermiculite	(1:1:1)
T_5	Coco peat + Perlite + Vermiculite + Vermicompost	(1:1:1:1)
T_6	Conventional method (soil + manure)	No definite ratio

Sampling time:

Sampling was done at 12 days after transplanting,

35 days after transplanting and at harvest (50 days after transplanting).

Observations:

The following observations were recorded at seedling, vegetative and reproductive stages.

Relative water content (RWC %) :

For RWC, the second or third fully expanded leaf from the top was brought from the NFT in polyethylene bags and stored in an ice box. Immediately, twenty leaf discs were weighted on electronic balance (Citizen Scale, CY510, Poland) and Fresh Weight (FW) was determined. The weighted leaf discs were floated overnight in a petridish containing distilled water and subsequently blotted gently and weighted again for Turgid Weight (TW). After taking turgid weight, the leaves were oven dried at 80ºC for 48 h and Dry Weight (DW) was recorded separately. The RWC was calculated using the following formula (Weatherly, 1950).

$$\text{RWC \%} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Turgid weight} - \text{Dry weight}} \times 100$$

Water use efficiency:

The ability of crops to take up and utilize water for maximum yield.

Statistical analysis :

The parameters recorded were analysed using Statistical tool - Factorial Completely Randomized Block Design (CRBD) for three factors. Treatments were compared using critical difference (CD) at 5 % level of significance. Data was subjected to analysis of variance (ANOVA) using Online Statistical Analysis Package (OPSTAT, Computer Section, CCS Haryana Agricultural University, Hisar 125004, Haryana, India).

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Relative water content (RWC %) of leaf:

The relative water content (RWC) in case of *Romaine* leaves was markedly increased in plants treated with treatment T_5 and T_4 (48.47% and 41.31%) whereas non significantly increased when treated with treatment T_1 (33.36 %) followed by treatment T_2 (34.85 %) and T_3 (39.57 %) respectively at 12 DAT in comparison to treatment T_0 and T_6 (24.17% and 20.73 %). As evident from Table 9, the plants treated with various combination of treatment T_1, T_2, T_3, T_4, T_5, the RWC was significantly increased (45.35 %, 45.46%, 50.53%, 55.51%, 60.89 %) and (30.93%, 32.10%, 37.10%, 39.57%, 44.90 %) at 35 DAT and 50 DAT in comparison to treatment T_0 and T_6 (45.13%, 24.10 %) and (22.56%, 27.84 %). Highest mean of RWC was founded at 35 DAT (46.71 %) and lowest was found at 50 DAT (33.57 %) respectively. Under different treatment maximum mean was noticed in treatments, T_5 (51.42%) as compared to other treatments. Whereas in *Grand rapid*, the relative water content of leaves was markedly increased in plants treated with treatment T_5 and T_4 (37.79% and 36.03 %) whereas non significantly increased when treated with treatment T_1 (30.85 %) followed by treatment T_2 (30.93%) and T_3 (32.19 %) respectively at 12 DAT in comparison to treatment T_0 and T_6 (28.13% and 24.11 %). Yet the plants treated with various combination of treatment T_1, T_2, T_3, T_4, T_5, the RWC was significantly increased (43.31%, 45.77%, 49.64%, 52.24%, 54.54 %) and (22.56%, 30.40%, 30.93%, 32.11%, 34.32 %) in comparison to treatment T_0 and T_6 (38.58% and 33.10%) and (20.40% and 10.99 %) at 35 DAT and 50 DAT respectively. Highest mean value in RWC was founded at 35 DAT (45.31 %) and lowest was found at 50 DAT (25.96 %). Under different treatment maximum mean was noticed in treatments, T_5 (42.22 %) as compared to other treatments.

Water use efficiency (WUE: Kg L^{-1} FW):

Table 17 depicts water use efficiency was maximum for both varieties grown hydroponically as compared to conventional method. At the time of harvest, water use efficiency for *Romaine* was 0.49 Kg L^{-1} as compared to conventional method (0.10) whereas, water use efficiency for *Grand rapid* 0.37 Kg L^{-1} as compared to conventional method 0.06 Kg L^{-1} respectively.

Relative water content of leaves:

Relative water content is utilised as a measure of plant water status because it expresses the absolute quantity of water required by the plant to achieve full artificial saturation while also representing metabolic activity in tissues and is recognised as a most useful index for dehydration tolerance. RWC related to water uptake

by the roots as well as water loss by transpiration. The relative water content of leaves of both varieties were significantly decreased in treatment T_6 (conventional method) as shown in Table 1 and Fig. 1 due to improper pH, EC and nutrients, they easily exposed to stress. Maximum RWC % were obtained for the plants treated with T_5(coco peat+ vermiculite + perlite + vermicompost) because in nutrient film technique, plants reduced damages by maintaining an optimum water status; to this aim, a set of compatible solutes are synthesized, namely water-soluble carbohydrates and other nutrients that are easily available to plants through nutrient solution.These components help cells to maintain their turgor pressure of leaves and help to acclimatize from environmental stress. Sankhalkar *et al.* (2019) supports our findings. They showed that the seedlings of *Pisum sativum* (pea), *Abelmoschus esculentus* (okra) and *Vigna radiata* (moong) grown in soil had lower relative water content

Table 1: Effect of different growing media on relative water content (RWC %) of *Romaine* and *Grand rapid* lettuce

Treatments	Relative water content (RWC %) of leaf							
	Romaine				*Grand rapid*			
	Days after transplanting (DAT)				Days after transplanting(DAT)			
	12	35	50	Mean	12	35	50	Mean
T_0	24.17	45.13	22.56	30.62	28.13	38.58	20.40	29.03
T_1	33.36	45.35	30.93	36.58	30.85	43.31	22.56	32.24
T_2	34.85	45.46	32.10	37.43	30.93	45.77	30.40	35.70
T_3	39.57	50.53	37.10	42.40	32.19	49.64	30.93	37.59
T_4	41.31	55.51	39.57	45.46	36.03	52.24	32.11	40.13
T_5	48.47	60.89	44.90	51.42	37.79	54.54	34.32	42.22
T_6	20.73	24.10	27.84	24.22	24.11	33.10	10.99	22.73
Mean	34.64	46.71	33.57		31.43	45.31	25.96	
C.D. at 5%	Variety				=1.26			
	Treatment				=2.37			
	Variety x Treatment				=3.35			
	DAT				=1.55			
	Variety x DAT				=2.19			
	Treatment x DAT				=4.10			
	Variety x Treatment x DAT				= 5.80			

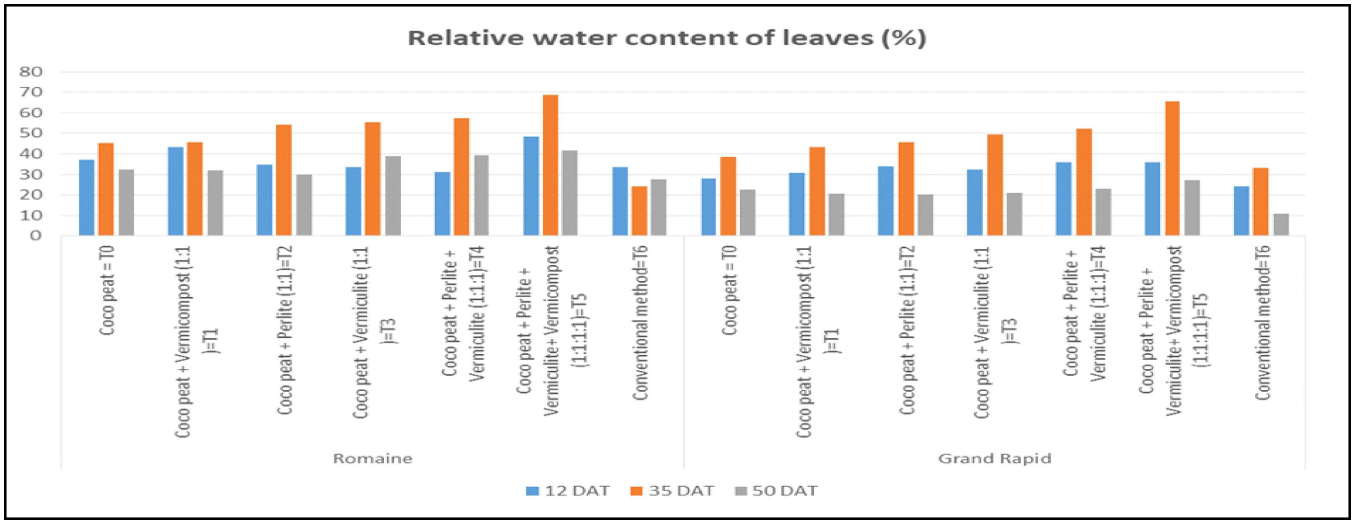

Fig 1: Graphical presentation showing relative water content (RWC%) of *Romaine* and *Grand rapid* lettuce under treatment of different growing media

Table 2: Effect of water use efficiency associated with hydroponic and conventional method

Treatments	Water use efficiency (WUE : Kg L^{-1} FW)	
	Romaine	*Grand rapid*
	Days after transplanting (50 DAT)	Days after transplanting (50 DAT)
Hydroponics	0.49	0.37
Conventional method	0.10	0.06

than the ones grown in hydroponics.

Water use efficiency:

Water use efficiency (WUE) is a measure of a crop's capacity to convert water into plant biomass or yield. When the plants were grown under different ratio of growing media in hydroponic, we noticed that treatment T_5, application enhanced the photosynthetic rates, chlorophyll content and high yield with minimum usage of water Table 2 and Fig. 2. Grewal *et al.* (2011) on cucumber crop and Lopez *et al.* (2011) on tomato crop complement our findings; they discovered that using hydroponics to produce crops in greenhouses is highly efficient in water consumption due to lower losses due to evaporation and percolation. Komosa *et al.* (2011) showed that closed hydroponic systems are more efficient in using water and nutrients than open systems due to recirculation of nutrient.

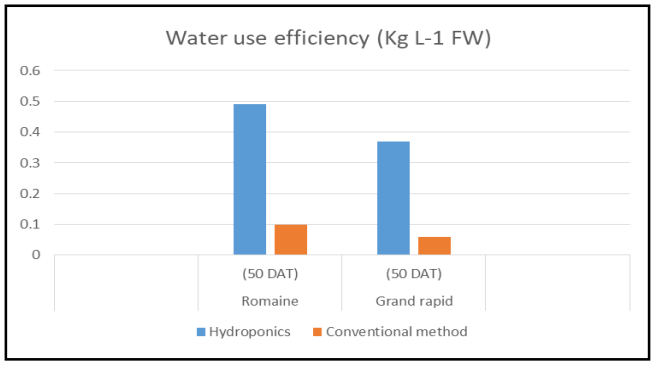

Fig 2: Graphical presentation showing water use efficiency of *Romaine* and *Grand rapid* lettuce under different growing methods

Conclusion:

Nutrient film technique is helpful for maintaining water relations, nutrient balance and adequate oxygen level, also avoid soil- borne pest and diseases as well as land degradation. With these considerations and in view of the economic importance of *Romaine* and *Grand rapid* as an important salad of India as well as of the world. Application of coco peat + perlite + vermiculite + vermicompost in the ratio of 1:1:1:1 and coco peat + perlite + vermiculite in the ratio of 1:1:1 at 12 DAT, 35 DAT and at 50 DAT increased the per cent RWC of leaves. Minimum RWC was noticed in plants treated with conventional method and those treated with coco peat alone (100 %). Due to effective use of nutrient film technique treatment of coco peat + perlite + vermiculite + vermicompost in the ratio of 1:1:1:1 increased the yield per plant with minimum use of water hence, increased the water use efficiency (WUE) of crop plants. Therefore, maximum WUE was also recorded in plants treated with coco peat + perlite + vermiculite + vermicompost in the ratio of 1:1:1:1 in hydroponics in comparison to conventional method.

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