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SEED POTATO PRODUCTIVITY AS INFLUENCED BY ELECTRICAL CONDUCTIVITY OF THE NUTRIENT SOLUTION IN SOILLESS MEDIA DURING SPRING SEASON IN SUBTROPICAL REGIONS OF N- W INDIA

Sugani Devi[1], R P Kaur[1]*, Brajesh Nare[1], Khushdil Bharti[2] and Anil Sharma[1]

ABSTRACT: Soilless cultivation under controlled conditions is used for rapid multiplication of early generation virus-free potato seed using aeroponics and other mediums. The plant growth under these systems is affected by different factors like soilless media, nutrient solution concentration used, environment, genotype etc. Besides the composition of nutrient solution its electrical conductivity (EC) influences availability of nutrients and affects plant growth and yield. The two-factorial study on water source and EC was carried out on a cocopeat based medium for a nutrient efficient variety Kufri Gaurav. Well sprouted aeroponically produced minitubers of the variety were planted (at 30 x 15 cm planting density) in soilless medium filled troughs placed under net house. The water source normal tap water was compared with RO (demineralized) water, while EC was considered at three levels 1.0, 1.5 and 2.0. The results indicated a proficient growth of the genotype at EC 2.0 (plant height, number of leaves, stem diameter, leaf length and number of stems). However, for the yield characters, EC 1.0 was found to produce both higher number of tubers, yield as well as harvest index per meter square. Based on the observations it can be inferred that at lower EC the partitioning of the photosynthates is towards the sink (tubers) as compared to the vegetative growth, which would be more desirable under the soilless systems, where limited/ managed canopy growth is more desirable, with higher productivity. The study also indicated virus free seed production in soilless medium during the spring season (seed plot period lasts up to December) in northwestern plains of India under net house, giving indication for successive/ multiple seed crops under soilless controlled conditions.

KEYWORDS: Soilless cultivation, Electrical conductivity (EC), aeroponics, minitubers, potato

INTRODUCTION

Potato is a global crop cultivated throughout the world across varying climates and terrains. The crop produces the maximum calories per unit area and time, making it an important crop identified for addressing the looming food insecurity in face of rapidly increasing world population. There has been consistent increase in potato area and production over the years.

India has emerged as the second largest producer of potato in the world after China with 54.23 mtons (FAO STAT, 2023). Out of the total production achieved in the country, the great Indian plains contribute more than 90 % production and area. The crop is grown here under short day conditions in the winter months from October to March of succeeding year. However, a short growing period, rapid degeneration of potato seed and its slow multiplication rates, decrease overall productivity of the crop in the region. Further, only the north western plains of India offer ideal conditions for growing seed using the seed plot technique and positive selection, where a low vector (white flies and aphids) period is observed from Mid-October to December end allowing cultivation of virus free seed. In view of this limitation and with

[1]ICAR- Central Potato Research Station, Jalandhar, Punjab-144 003, India
[2]PhD scholar, Punjab Agricultural University, Ludhiana, Punjab-141 004, India
*Corresponding author; email: kaur.rp@gmail.com

the objective of increasing early generation seed, hi tech seed systems have been developed in the country. Virus free tissue culture microplants are grown in net houses and aeroponics under controlled conditions, during the potato growing period. Although using these facilities cultivation period can be extended beyond the seed growing period, the aeroponics facility is limited by its high cost and net house by the soil borne pathogens. In such a scenario, soilless (SL) cultivation becomes a prospective option offering several advantages.

SL cultivation is generally carried out in cocopeat based medium and supplemented with macro and micro nutrients to achieve optimum growth. Various factors like pH, nutrient medium composition, SL media, EC, genotype, climate etc. reportedly affect SL cultivation. Several SL mediums have been reported for potato minituber production (Awati *et al.* 2019). Similarly, CPRI-Aeroponic nutrient solution has already been standardized for potato growth in the region. However, EC of solution and source of water under SL cultivation (coco peat based) has not been evaluated, which can affect both plant growth and cost of cultivation. Electrical conductivity is an important parameter governing plant growth and is known to affect photosynthesis, quality and antioxidant enzyme activity in plants (Savvas *et al.* 2008; Signore *et al.* 2016; Ding *et al.* 2018). It defines the index of salt concentration and is used as an indicator for electrolyte concentration of the solution. Studies on EC for aeroponic cultivation were done by (Calori *et al.* 2017) in Brazil for two cultivars Agata and Asterix in the winter/ spring conditions, using different plant densities. They reported that EC of 2.2 and 2.1 dS m^{-1} gave the highest productivities. However, their study was under aeroponics for Brazil, so it needs standardization for not only cocopeat media systems but also based on the Indian agroclimate and Indian potato varieties. Development of efficient SL cultivation system will go a long way in increasing climate resilience and increasing production of early generation seed, ensuring increased availability in the country in advanced generations (Awati *et al.* 2019; Pradhan and Deo, 2019). The present study also evaluated the effectiveness of cultivation of potato seed beyond January in the North western plains under SL conditions. This can be a significant intervention to further increase early generation seed by taking two successive seed crops in SL controlled conditions. Successive cropping under net house has been reported previously from the same region by (Kaur *et al.* 2021).

MATERIAL AND METHODS

The experiment was conducted in the insect-proof net house of ICAR-Central Potato Research Institute (Regional Station), Jalandhar (31°23′N and 75°79′E, altitude 237 m amsl) 2020-21. Aeroponically produced Minitubers of variety Kufri Gaurav (weighing 2–5 g) were withdrawn from the cold store and allowed to sprout under diffused light at 22-24°C for 20 days and planted in the third week of February at the spacing of 30 x 15 cm (row to row x plant to plant). Cocopeat media was sterilized by drenching with Nano silver hydrogen peroxide (3%) followed by thorough washing with clean water. Growing containers (troughs) of size 600 cm x 100 cm, made of HDPE sheet of 700-micron thickness was placed on a raised bench and used for planting of these sprouted minitubers. Nutrient management in this cocopeat soilless culture (CSC) was done using the standardized ICAR-CPRI liquid formulation containing macro and micro essential nutrient elements. EC of the solution was regulated through dilution with water to maintain EC and pH. All cultural practices for net house cultivation, recommended for the region were followed with haulm cutting at approximately 60 days, in all the treatments.

Experiment was carried out using factorial RBD with two factors with three replications. The first factor water source had two treatments Tap water (TW) and R.O. purified water (without mineralization) (RO). For the second factor electrical conductivities at 1.0 (1.0EC), 1.5 (1.5EC) and 2.0 (2.0 EC) mS/cm were considered. Observations were recorded on various plant growth and yield parameters. Growth observations (plant height (PH), number of leaves (NL), leaf length (LL), leaf breadth (LB), stem diameter (SD), number of stems (NS)) for five plants in a single replication were recorded at 30 and 55 days to evaluate the growth pattern of different treatments. The data was analyzed statistically by using 2 factor analysis of variance (ANOVA). Mean values were calculated and separated using F-test at 5% level of significance and means of different treatments were compared using critical difference (CD).

RESULTS AND DISCUSSION

The effect of EC and water source on growth and yield have been summarized as follows:

Plant height (PH): Plant height at 30 DAP showed significant difference among different EC of nutrient solution but water source used for irrigation had not affected plant height at 30 DAP. The tallest plants (27.83 cm) were recorded in 2.0EC; shortest (19.50 cm) plants were produced with 1.0EC (Table 1). This may be due to faster growth of plant with more available nutrients with higher electrical conductivity of nutrient solution. Plant height at 55 days was influenced by both water source and EC of nutrient solution and maximum plant height was observed with RO water among water sources and with 2.0EC among different EC.

Number of leaves (NL): The source of water showed non-significant differences between different treatments for number of leaves at 30 DAP as well as 55 DAP under SL media. However, EC showed significant results as highest number of leaves were observed with 2.0EC (13.78) at 30 DAP and 55 DAP (18.83). More number of leaves are desirable for photosynthetic activity in the plant.

Leaf length (LL) and breadth (LB): Leaf length and breadth of 4th leaf from the top was measured at 30 DAP. More leaf length

Table 1. Growth parameters as influenced by water source and EC.

	PH30	PH55	NL30	NL55	LL30	LB30	SD30	NS55
Water Source								
RO	23.93	54.18	13.30	17.74	15.01	7.91	6.41	4.00
TW	23.59	50.89	13.04	17.48	17.43	8.66	6.93	3.998
SEM	0.528	0.897	0.180	0.359	0.282	0.245	0.203	0.350
LSD (0.05)	NS	2.863	N.S.	N.S.	0.900	N.S.	N.S.	NS
Electrical Conductivity								
1.0 EC	19.50	37.61	12.50	15.22	14.75	7.87	5.61	2.72
1.5 EC	23.95	58.11	13.22	18.78	16.20	8.10	7.11	3.66
2.0 EC	27.83	61.89	13.78	18.83	17.73	8.90	7.29	5.61
SEM	0.674	1.099	0.221	0.440	0.345	0.300	0.249	0.428
LSD (0.05)	2.064	3.507	0.705	1.404	1.102	N.S.	0.795	1.366

Note: PH30- Plant height at 30 DAP; PH55- Plant height at 55 DAP; NL30-Number of compound leaves per plant at 30 DAP; NL55- Number of compound leaves per plant at 55 DAP; LL30- length of 5th leaf from top at 30 DAP; LB30- Breadth of 5th leaf from top at 30 DAP; SD30- Stem diameter at 30 DAP; NS55- Number of stems at 55 DAP.

was obtained with tap water (17.43 cm) compared with RO water (15.01). Regarding effect of EC, it was recorded that maximum leaf length was observed for 2.0EC followed by 1.5EC. Results of leaf breadth were non-significant for both the factors.

Stem diameter (SD): Stem diameter is a desirable growth parameter of plant as it provides stable and sturdy plants in soilless media. Stem diameter was measured at 30 DAP and was significantly affected by EC of nutrient solution. It was observed that the stem diameter of plants irrigated with tap water was non-significantly higher than RO water irrigated plants. Regarding stem diameter with different EC, it was found that the significantly highest diameter was observed in 2.0EC (7.29 mm) which was found at par with 1.5EC (7.11 mm) and lowest in 1.0EC (5.61 mm).

Stems/plant (NS): More stems per plant were observed with higher EC of nutrient solution compared to lower EC. The difference in plant vigor may be due to abridged availability of nutrients for the plants to develop to their full vigor under higher EC's. Highest number of stems were observed with 2.0 EC (5.61) followed by 1.5EC (3.66).

Total number of tubers/m^2 (TN): A significant difference (P≤0.05) was noted in the number of tubers (per m^2) obtained with different electrical conductivities (Figure 1). Interesting results were observed regarding tuber number, although results were non-significant for differences in water source, a greater number of tubers were observed in TW. Regarding effect of EC, it was observed that significantly highest tuber number per m^2 were recorded with 1.0 EC (200.91) which was statistically at par with that of 1.5 EC (180.54).

Total tuber yield/m^2 (TW): Although the tuber yield per m^2 differed non-significantly among water sources, electrical conductivity of water

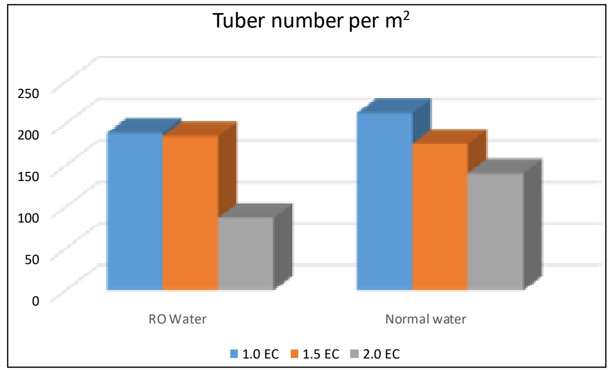

Fig.1. Tuber number/m^2 as influenced by water source and EC.

significantly influenced the yield just similar to tuber number. Tap water irrigated plants produced higher tuber yield as compared to RO water irrigated, although difference was non-significant. When we compared tuber yield between different EC within same water source, the trend was 1.0 EC (3461.69 g) followed by 1.5 EC (2745.09 g) and lowest yield with 2.0 EC (1126.74 g).

Harvest Index (HI): It is evident from the table 2 that the influence of water source as well as electrical conductivity with respect to harvest index, depicted significant variation under insect-proof net house. TW irrigated

Table 2. Yield parameters as influenced by water source and EC.

	TN	TW	HI
Water Source			
RO	153.69	2226.32	31.29
TW	176.53	2662.70	41.47
SEM	10.922	150.685	1.556
LSD (0.05)	NS	NS	4.966
Electrical Conductivity			
1.0 EC	200.91	3461.69	58.84
1.5 EC	180.54	2745.09	35.82
2.0 EC	113.88	1126.74	14.47
SEM	13.376	184.550	1.906
LSD (0.05)	42.694	589.044	6.082

Note: TN-represents here tuber number per m^2; TW-tuber weight per m^2; HI-Harvest index plants produced more HI than RO water irrigated. The maximum value of harvest index was observed 1.0 EC (58.84 percent) followed by 1.5 EC (35.82 percent) and minimum in 2.0 EC (14.47 percent). The higher value of harvest index with 1.0 EC indicated plants produced higher tuber yield with minimal biological yield.

The results indicated a proficient growth of the genotype at EC 2.0 (plant height, number of leaves, stem diameter, leaf length and number of stems). However, for the yield characters, EC 1.0 was found to produce both higher number of tubers, yield as well as harvest index per meter square. Based on the observations it can be inferred that at lower EC the partitioning of the photosynthates is towards the sink (tubers) as compared to the vegetative growth, which would be more desirable under the soilless systems, where limited/ managed canopy growth is more desirable, with higher productivity. The study also indicated virus free seed production in soilless medium during the spring season (seed plot period lasts up to December) in northwestern plains of India under net house, giving indication for successive/ multiple seed crops under soilless controlled conditions. In the study by Kaur *et al.*, 2021 two successive crops from minitubers were planted (October-April). Successive dual cropping resulted in 2.52 times higher tuber number as compared to single cropping (November- January) under net house cultivation in N-W plains.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest

ETHICAL STATEMENT

This article does not contain any studies with human participants or animals performed by any of the authors

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