EVALUATION OF POTATO *IN VITRO* PLANTS WITH DIFFERENT INTER AND INTRA-ROW SPACING IN SOILLESS SYSTEM UNDER INSECT PROOF NET HOUSE

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ABSTRACT: Availability of disease-free quality seed material is the urgent need for improving potato productivity. *In vitro* plants of potato are the pure form of seed and are free from disease pest contamination. The present study was undertaken under an insect-proof net house to evaluate the performance of microplants of two potato varieties (*Kufri Pukhraj* and *Kufri Himalini*) at three different planting densities. The results of the experiment reveal that for getting the maximum number and yield of mini-tubers from *in vitro* plantlets under soilless culture in insect-proof net house, we should increase planting density to 66 plants per m^2 (spacing of 15X10 cm). In a mini-tuber production scheme, it is always important to get yield in terms of numbers in relation to the size. The multiplication rate in potato seed production is low (4-5 times), hence it is always desirable to increase the number of tubers produced at harvest even if some compromise has to be done with the size of tubers. Since both the number and weight of minitubers obtained was higher at closer spacing, it is better to reduce the spacing to accommodate more plants resulting in the production of more number of tubers in the same area.

KEYWORDS: *Solanum tuberosum*, microplants, aeroponic tubers, plant geometry, early generation seed

INTRODUCTION

Potato *(Solanum tuberosum* L.*)* is third most economic non cereal crop after rice and wheat in India. Potato has been identified as a future crop for meeting food security issues (Singh and Rana, 2013). It contributes as important source of income across the world's farming community. Potato provides food and nutritional security and also helps to eliminate poverty in developed and developing countries. India has emerged as the second largest producer of potato in the world after China with contribution of 13.54% in production and 11.24% in area in world potato cultivation (NHB, 2019 and FAOSTAT, 2017). Potato can be grown from seed tuber size ranging from 30 to 55 mm diameter and require 2-3 t/ha average seed rate. In Asia, India is only a country which have well predictable seed production program and ICAR-CPRI singly produces breeder seed about 3,000 metric tonnes annually. In the last 65 years, country has made marvellous progress in the production of potato due to release of number of high yielding varieties which are resistant to different disease or pest with advanced technological interference, appropriate for different agro-climatic condition of the country. Seed Plot Technique development contributes massively to the production of quality seed potato on large scale. Keeping in view the deteriorating potato seed health under field conditions, quality seed production can be increased by adopting measures to check seed stock degeneration. Struik and Wiersema (1999) directly correlated high potato yields with use of high quality, certified seed tubers.

Hi tech seed production systems advanced in recent years satisfactorily counter the issues of low rate of seed multiplication under conventional seed production system

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(Badoni and Chauhan, 2010) and increasing demand of quality seed material. Hi tech seed system includes different rapid multiplication techniques like tissue culture, net house multiplication and aeroponics. The disease-free tested potato microplants are multiplied in tissue culture followed by its further multiplication in net house or aeroponics to produce G0 minitubers. Now the problem with aeroponics is that it is very expensive and not affordable to small and medium farmers and need technical knowledge for crop management. In vector proof net house in spite, of a longer cropping season in northern India lasting from October to April, only one potato seed crop is being grown in one crop season in soil as there is risk of soil borne diseases in successive dual crop. Technologies and strategies to increase productivity at the earliest seed stages can have profound effect on overall seed production (Kaur *et al*., 2019). There are different types of alternate media that plants can grow as well in it. For potato production, cocopeat as soilless media is most popular which is made from cocopeat fiber powder. Having different properties of cocopeat includes as easy absorbing and saving water and also have pores that facilitate the exchange of air resulting provide favourable condition for root development of plant. So, we can use soilless media like cocopeat which can be successfully sterilized between two crop cycles and the precious net house area can be proficiently utilized by taking multiple crops. The technical information is still lacking in potato for soilless minitubers production like crop geometry, nutrients, crop duration; crop management practices *etc.* which can be further improve the productivity of early generation seed material. For any potato seed program, obtaining many medium sized mini-tubers is more important than producing few large mini-tubers (Love *et al*., 2003). Therefore, many studies have been conducted to establish the optimal combination of seed size and planting distance for a certain environment (Entz and La Croix, 1984; Negi *et al*., 1995; Bussan *et al*., 2007). They concluded that yield increased with choosing lesser plant spacing. Keeping in view these facts the study was conducted to find out the best planting geometry under cocopeat medium for maximization of multiplication rate of disease free minitubers from *in vitro* plants.

MATERIALS AND METHODS

The study was conducted at CPRS, Jalandhar in insect-free net house to find out the best planting geometry for tissue cultured potato plants under cocopeat medium. Hardened microplants of two varieties (K. Himalini and K. Pukhraj) were shifted in soilless beds on 5 November 2020 in insect proof net house with three plant densities (PDs) replicated three times.

In vitro propagation of plantlets

Only virus free plantlets propagated through micropropagation were used. In vitro plants were propagated routinely at tissue culture laboratory at CPRS, Jalandhar. Single node cuttings were sectioned and placed in test tubes (1 cutting per tube) on fresh MS medium (Murashige and Skoog, 1962). Sub culturing of microplants was performed once every 3-4 weeks. The temperature in growth room was 20-22°C; photoperiod was 16/8 h day and night respectively.

Planting of in vitro plantlets and crop husbandry practices in soilless media under insect proof net house

The longer adventitious roots of microplants were trimmed off slightly and then planted in pro trays in coco-peat media and hardened for about 20 days. Hardened microplants of two varieties (K. Himalini and K. Pukhraj) were shifted in soilless beds at four PDs- 22 plants m^{-2} (D_1), 44 plants m^{-2} (D_2) and 66 plants m^{-2} (D_3) respectively. Before planting cocopeat media was sterilized with Nano silver hydrogen peroxide 3 percent solution by drenching followed by thoroughly washing with clean water. Growing containers (troughs) of HDPE sheet of 700 micron thickness was placed on a raised bench and used for planting of *in vitro* plantlets. For nutrient management in cocopeat soilless culture, ICAR-CPRI liquid formulation containing macro and micro essential nutrient elements was given after dilution with water to maintain EC range between 1.5-2.0 and pH range of 6.0 to 6.5. All cultural practices recommended for the region for net house cultivation were followed with haulm cutting at approximately 90 days in all the treatments.

Experimental design and statistical analysis

Experiment was carried out with factorial RBD with two factors; varieties (K. Pukhraj & K. Himalini) and planting densities (D1, D2 and D3) with three replications. Observations were recorded on various plant growth and yield parameters. Survival percentage was recorded at 30 days after shifting in net house (DAP). Growth observations for five plants in a single replication were recorded at 30 and 60 days to evaluate the growth pattern of two varieties in different crop geometries. It was further averaged to derive the respective values for each replication. Harvested tubers were classified into two categories undersize (below 3 g) and seed size (3- 30 g). Category of oversize tubers (>30 gm) was not considered as none of the tubers were found above 30 g due to closer row to row planting of 30 cm. Tuber number and yield of under size and seed size tubers were depicted as NUT (Number of undersize tubers/ m^2) and WUT (weight of undersize tubers/ m^2) and NST (Number of seed size tubers/ m^2) and WST (weight of seed size tubers/ m^2), respectively. Similarly, total number and weight of the tubers were depicted as TN (total tubers/ m^2) and TW (total weight of tubers/ m^2). The average was analyzed statistically by applying the technique of analysis of variance (ANOVA). Mean values were calculated and separated using F-test at 5% level of significance.

RESULTS AND DISCUSSION

Total number of tubers per m^2 (TN)

Tuber number is an important character which determines the multiplication rate in potato and is most crucial for seed potato production. Planting density of *in vitro* plants and cultivar had significant effect on number of minitubers per m^2 and tuber yield (Table 2). This finding confirms results obtained by Kumar *et al.*, 2012 and Kaur *et al*, 2019. No significant interaction effect was found between varieties and PDs. The variety Kufri Pukhraj (446.28) significantly outyielded variety K. Himalini (259.94) for total number of tubers produced per m^2. The characters showed significant differences among different PDs. As expected earlier significantly maximum tuber number per m^2 was obtained with higher plant density D3 (482.46) followed by D2 (354.42) and minimum with D1 (222.46), the lowest plant density. Increase in number at higher plant density might be due to the corresponding higher number of stems available per unit area on account of more number of plantlets planted. More number of tubers per unit area with increasing plant population has been reported to occur on account of more number of stems per unit area in conventionally grown potato (Kumar *et al.*, 2011; Kushwah and Singh, 2008; Malik *et al.*, 2000 and Zamil *et al.*, 2010) as well as in the mini-tubers raised from *in vitro* plantlets (Kumar *et al.*, 2012).

Yield per square meter (TW)

The yield is indicative of the total weight of tubers obtained per metre square for different planting density treatments. Significant differences for yield over variety and density were obtained (Table 2). The significantly higher yield was obtained for the variety Kufri Pukhraj as compared to variety Kufri Himalini. Among the PD treatments included in the study D2 and D1 showed at par yields, which were however significantly lower than the D3 treatment means. Comparatively higher proportions of large sized mini-tubers obtained at low plant density and vice-versa can be attributed to the increasing competition between plants for space and nutrients coupled with higher number of mini-tubers obtained per unit area at high plant density**.** Whereas, per plant tuber yield is significantly higher at lower plant density and vice versa.

Seed size tuber number per m^2 (3-30 g)

Seed size mini-tubers indicate the economically most important class of tubers with respect to seed multiplication and vigour. The character number of seed size tubers depicted highly significant variations for variety and planting densities (Figure 1). Significantly higher tuber number was obtained in variety K. Pukhraj (347.85) than K. Himalini (224.01) on per m^2 basis. Higher planting density resulted in higher seed size minitubers per m^2. Among the PDs treatments, maximum number of seed size tubers was seen in D3 treatment which was significantly higher than the other PDs considered in the experiment, showing a 101.18% increase over D1. However, when we observed the data regarding number of seed size tubers per plant results are just opposite to per m^2 data. Seed size tuber number per plant was significantly higher in wider spacing D1 (8.61) which was followed by D2 (6.53) and D3 (5.78).

Increased or more number of tubers at high densities may be due to the fact that at low density plantings fewer sinks are produced per unit area and they increase with increasing planting density (Mangani *et al.*, 2015).

Undersize tuber number per m^2

Number of undersize tubers per m^2 was observed to be significantly influenced by

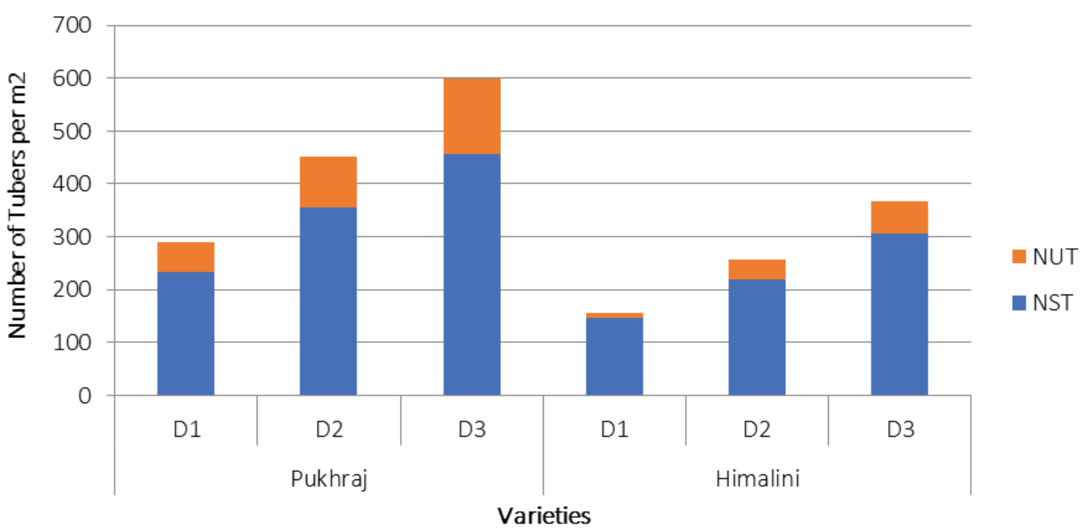

Fig. 1: Tubers number in different seed categories out of total tubers produced undersize (NUT) and seed size (NST) minitubers on per square meter basis for the two varieties Kufri Pukhraj and Kufri Himalini.

Table 1. Effect of different plant spacing on growth parameters in soilless culture in potato

Treatments/Observations	Plant Height (30 DAP)	Plant Height (cm) @ 60 DAP	No of leaves @ 30 DAP	No of leaves@ 60 DAP	SD (mm)
		Varieties			
K. Pukhraj	13.81	38.22	12.78	13.29	3.84
K. Himalini	23.04	51.48	13.96	12.48	2.26
LSD (0.05)	2.315	3.86	0.978	NS	0.284
SEm±	0.725	1.210	0.306	0.318	0.089
		Plant Density			
30X15(D1)	18.72	42.72	14.17	14.83	3.39
15X15 (D2)	19.22	45.28	13.17	11.72	2.89
15X10 (D3)	17.33	46.56	12.78	12.11	2.87
LSD (0.05)	NS	NS	NS	1.242	0.348
SEM	0.888	1.482	0.375	0.389	0.109

Table 2. Effect of different plant spacing on yield parameters in soilless culture in potato

Treatments/Observations	Number of seed size tubers per plant	tuber weight (g) per plant)	NST	NUT	TW
		Varieties			
K. Pukhraj	8.51	79.74	347.85	98.44	3003.22
K. Himalini	5.43	76.35	224.01	35.93	2846.10
LSD (0.05)	0.608	NS	22.566	31.784	NS
SEm±	0.191	3.547	7.070	9.958	138.481
		Spacing			
30X15(D1)	8.61	120.95	189.46	33.00	2660.79
15X15(D2)	6.53	61.67	287.17	67.25	2713.33
15X10(D3)	5.78	51.53	381.15	101.31	3401.20
LSD (0.05)	0.745	13.867	27.637	38.928	541.338
SEm±	0.233	4.344	8.659	12.196	169.604

variety and planting density. Significantly higher tuber number of this category was depicted in variety K. Pukhraj (98.44) than in K. Himalini (35.93) on per m^2 basis. Regarding impact of PDs, significantly highest number of undersize tubers were obtained in narrower spacing D3 (101.31) and the minimum as expected were for lower planting density D1 (33.0). It was therefore observed that higher number of undersize minitubers is formed at higher density, but their proportion out of total also increases simultaneously. The proportion of undersize tubers out of total produce was higher in denser planting of 66 plants per m^2D3 (20.99%) than lower plant density of 22 plants per m^2 (14.83%). Although, tubers of this category are not preferred as seed but are viable up to a certain lower limit below which the viability of minitubers may be lost due to shrinkage in storage and are further recycled/multiplied.

Growth parameters

Plant height

The variety Kufri Himalini showed higher plant height than Kufri Pukhraj (Table 1). The maximum plant height was obtained in D3, though it was not significantly tall than all the other treatments included in the study which were at par. This gives an inference that the plants grew taller in response to higher density in face of competition for more light.

Number of leaves per plant

The character showed (Table 1) significant variation for varieties at 30 DAP and for plant density at 60 DAP and not for their interactions. The significantly higher number of leaves per plant at 30 DAP were observed in the variety Kufri Himalini (13.96) than Kufri Pukhraj (12.78) because of more plant height. The plant density treatment D1 showed the maximum number of leaves (14.83) at 60 DAP followed by D3 and D2 which were at par statistically. The observation corresponds to more aerial space for growth of canopy in D1.

Stem diameter (SD)

Stem diameter was measured at 30 DAP and was significantly affected by variety as well as by plant densities (Table 1). It was observed that stem diameter of plants of Kufri Pukhraj (3.84 mm) was significantly higher than Kufri Himalini (2.26 mm). Regarding stem diameter in different plant spacing, it was found that significantly highest diameter was observed in D1 (3.39 mm) plant spacing followed by D2 (2.89 mm) and D3 (2.87 mm) which are found at par to each other. This may be due to increased competition among the plants for space and other nutrients resulting in weak stems under narrow spacing treatment.

CONCLUSION

The results of the experiment reveal that for getting maximum number and yield of mini-tubers from *in vitro* plantlets under soilless culture in insect proof net house, we should increase planting density to 66 plants per m^2 (spacing of 15X10 cm). In a mini-tuber production scheme, it is always important to get yield in terms of numbers in relation to the size (Park *et al*., 2009). The multiplication rate in potato seed production is low (4-5 times), hence it is always desirable to increase the number of tubers produced at harvest even if some compromise has to be done with the size of tubers.

Multiplication rates achieved in the early seed multiplication generation has greater implication during subsequent seed multiplication generations. The multiplication of early generation seed up to 6-8 times before supply to farmers is generally practiced in India. Based on the results of the present experiment it can be postulated that a small intervention by increasing planting density under cocopeat medium in net house in early seed multiplication generations can be used favorably and economically to increase minituber production. Since both number and weight of minitubers obtained was higher at closer spacing, it is better to reduce the spacing to accommodate more number of plants resulting in production of more number of tubers in the same area.

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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