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Growth and yield of potato (*Solanum tuberosum* L.) as influenced by biostimulant under soilless culture system

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Abstract
The present investigation on "Growth and Yield of Potato (*Solanum tuberosum* L.) as Influenced by Biostimulant under Soilless Culture System," was conducted in the glasshouse at Bidhan Chandra Krishi Viswavidyalaya, Department of Vegetable Science, Faculty of Horticulture, during the year 2020-21. The purpose of this study was to investigate six commercial varieties of potato in order to identify the most suitable variety and to investigate the best biostimulant under soilless culture system. The experiment was laid out in Completely Randomized Design with three replications. The treatment consists of six varieties viz. (Kufri Jyoti, Kufri Chandramukhi, Kufri Himalini, Kufri Gaurav, Kufri Khyati, Kufri Pokhraj and two biostimulants pilatus (@ 1 ml/lt water) and goldstar (standard dose @ 2 g/li water) cultivated in the growing media- cocopeat, vermicompost, perlite and their 1:1:1 mixture. From the investigation it was observed that. Kufri khyati had the highest plant height (58.170 cm at 60 DAP and 61.233 cm at 90 DAP), the most tubers per plant (19.437) and the largest tuber diameter (6.667 cm) and the highest total yield per plant (1.303 kg/plant).All of these yield-related characteristics were discovered to be most effective in plants treated with Pilatus biostimulant. In terms of quality parameters, the variety Kufri Pokhraj contains the most total sugar (0.77%) and reducing sugar (0.512%). The variety Kufri Jyoti had the highest total soluble solids (7.115 o Brix). When it comes to quality parameters, goldstar exhibits the maximum values of total sugar (0.535%), reducing sugar (0.389%), total soluble solids (5.455◦Brix). Pilatus biostimulant was found to be most effective for growth and yield attributing characters whereas goldstar was found effective for quality traits. Overall it concluded that variety kufri khyati in application of Pilatus is best combination for cultivation of potato under soilless culture systems.

Keywords: Growth, yield, potato, *Solanum tuberosum* L., biostimulant, soilless culture system

Introduction
Vegetables, like other food crops, are traditionally grown in open fields and in soilless production methods. However, in recent decades, open/soil farming has faced some significant challenges. The most important of these is the sharp decline in per capita land availability. This was mainly attributed to the population explosion, industrialization and rapid urbanization in recent decades. In addition, recent climate change and subsequent melting of icebergs will also reduce arable land. In addition, intensive cultivation of crops in soil after the Green Revolution has led to low soil fertility, increased soil salinity, and higher incidences of pathogens. In addition, problems such as poor recycling of natural soil nutrients due to continuous cultivation, frequent drought conditions, unpredictability of weather patterns, temperature rise, groundwater level drop reduced food production under land-based conventional agriculture. If such a situation quickly escalates, it will be impossible to increase the quality of products by growing crops in the open field system in the coming days. Soilless cultivation currently offers a more relevant option to address these challenges. Soilless vegetable production has shown promising results worldwide. In unfavorable soil conditions, soilless cultivation can be a good option to produce healthy and high-quality vegetables. Of course, in the current scenario, the groundless culture is becoming more and more relevant to meet all these challenges.
Soilless culture is the technique of growing plants in soilless conditions, submerging their roots in a nutrient solution. Compared to soil cultivation, yields from soilless cultivation are significantly higher due to intensive practices and the possibility of continuous production throughout the year. A good growing medium would provide adequate anchoring or support for the plant, serve as a reservoir of sufficient nutrients and water for root functions, allow diffusion of oxygen to the roots, allow gas exchange between the roots and the atmosphere

outside the root substrate, and would create the Requirements for practical crop production, e.g., easy to supply, reasonable cost, ease of processing, ease, and production of homogeneous crops. While these growing media can be used alone, mixtures of growing media such as peat and perlite; Coir and clay, peat, and compost are also commonly used. Many crops can be grown using the soilless growing technique, such as fruits and leafy vegetables: peppers, tomato, cucumber, lettuce, spinach, etc. Flowering onion lily, flowering tulip and greenery: carnation, gerbera, etc. Whereas production of potato in soilless farming is not popular although studies have shown that soilless culture systems can be used as an effective technique to produce virus-free potato minitubers (Ritter *et al*. 2001) [8].

In order to avoid using excessive amounts of external inputs without compromising crop performance, it is essential for a sustainable potato production system to maximise soil nutrient availability and nutrient usage efficiency. Plant biostimulants could be quite beneficial to farmers in this situation. Liquid seaweed extract has recently gained traction as a foliar spray for many crops, including various types of herbs, flowers, grains, vegetables, and spices (Pramanick *et al*., 2013 and 2014) [6, 7]. Seaweed extracts can improve the quality and yield of crops. They are advantageous and increase crop yield by enhancing the germination of seedlings and the post-harvest shelf lives of perishable goods' (Hernández-Herrera *et al*. 2014) [2]. Seaweed extracts assist in increasing the antioxidant qualities and enhancing soil nutrient absorption (Turan and Kose 2004) [9]. In view of this, not much work has been done in this area in our country and information is lacking. On accounts of the above facts, the present investigation was frame out to study the "Growth and Yield of Potato (*Solanum tuberosum* L.) as influenced by Biostimulants under Soilless Culture System" with the objectives to Identify the best performing genotypes in terms of growth and yield of potato in soilless culture and to determine the best biostimulant response in potato grown in soilless culture.

Materials and Methods

The experiment was conducted under protected condition (glasshouse) of the Department of Vegetable Science, situated in the arena of Experiential Learning Unit, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal during the rabi season of year 2021-2022. The location of the experimental site is 23.5°N latitude and 80° E longitude with average altitude of 9.75 m above the mean sea level (MSL).The experimental site had assured irrigation facilities. The trial was laid out in Completely Randomized Design with twelve treatments, each replicated thrice. The treatment factors included six potato genotypes –Kufri Jyoti, Kufri Chandramukhi, Kufri Himalini, Kufri Gaurav, Kufri khyati, Kufri Pokhraj and two biostimulants pilatus (@ 1ml/lt water) and goldstar (standard dose @ 2 g/li water) cultivated in the growing media-cocopeat, vermicompost, perlite and their 1:1:1 mixture. All the substrates (Cocopeat, Vermicompost, Perlite,) were collected and the blocks of cocopeat were kept in water for 12 hours. Then, the substrates were mixed at 1:1:1: ratio and mixtures were prepared as Cocopeat + Vermicompost + Perlite. The prepared substrate mixtures were filled in the Growth bag equally. After filling properly, it was watered and after two days again substrates were filled to make the Growth bag compacted with the specified growing media. Collected tubers of different varieties are cut longitudinally through the crown eye and the weight of the cut pieces were around 30-40 g. The seed tubers are cut with a knife just and treated with a fungicide before planting. Before cutting the seed tuber, the knife is also disinfected with Potassium Permanganate solution. The whole or cut tubers are directly planted at a depth of 5-7 cm in the centre of the hole of the growth bag filled with growing media and covered substrates. Proper management with respect of irrigation and plant protection measures were undertaken.

Basal dose of fertilizer N:P:K (19:19:19) at 2 gm/li water was applied as foliar spray.1st dose of fertilizer was applied 30 days after planting and 2nd dose was applied another 30 days after first application. Both pH and electrical conductivity (EC) of the solution were checked two times during the growing period and kept close to the range of 5.5 – 6.5 and 2,000 µS cm^{-1}, respectively. Two Bio-stimulant was sprayed i.e. PILATUS @ 1ml/lt water and GOLDSTAR @ 2 g/li water. It was sprayed two weeks after planting then again20 days after first application. The observations were recorded at 60 and 90 DAT from randomly selected plants. The growth parameters were recorded throughout the growing period of the plants at appropriate stages. While the yield and quality parameters were recorded after the harvest of the crop.

Results and Discussion

Growth attributing characters

Among the two different biostimulant highest plant height 57.316 cm at 60 DAPS and 59.445 cm at 90 DAP was obtained when the varieties are treated with Pilatus. This might be due to better physio-chemical properties of the Pilatus biostimulant that helped in achieving higher plant height that the other biostimulant. Similar results were also confirmed with the findings of Haider *et al.* (2012) [3]. Regarding the varieties, highest plant height 58.170 cm at 60 DAP and 61.233 cm at 90 DAP was found from the variety Kufri khyati. Plant height variance within varieties may be attributable to genetic inheritance of the specific variety as well as temperature and environmental influences Plant height variance within varieties may be attributable to genetic inheritance of the specific variety as well as temperature and environmental influences. Number of leaves per plant due to different varieties showed statistically significant differences. It ranges from 36.277-48.243 at 60 DAP and in 90 DAP it ranges from 56.263 72.850. The maximum number of leaves per plant was observed in the variety Kufri Gaurav (V4) 48.243 and 72.850 at 60 & 90 days DAP. The Number of leaves per plant variation in within the varieties might be due to the fact that each variety may have an inheritance characteristic which force to produce maximum and minimum number of leaves per plants. Number of leaves per plant for different biostimulant was statistically significant for both 60 days and 90 days after planting analysis. Maximum number of leaves per plant was observed 41.260 and 63.361 at 60, 90 DAP respectively when the plants were applied with PILATUS, Kargapolova *et al*. (2020) [4] have worked with *Azospirillum brasilense* Sp245, SR80 and *Azospirillum halopraeferens* Au4T and reported significant growth promotion of potato in terms of number of leaves. Biostimulant Pilatus produces highest number of halums per plant 4.266 and 6.268 at 60 DAP and 90 DAP respectively than gold star biostimulant. Among the six different Variety

kufri himalini produced highest number of halums per plant (4.765 and 6.968) both in 60 DAP and 90 DAP. There was statistically significant effect of biostimulant as well as varieties on leaf area (cm^2). The result is represented in the table-1. Different varieties had statistically significant differences in leaf area per plant (cm^2). At 60 DAP, it ranges from 331.215 to 401.642 cm^2, while at 90 DAP, it ranges from 369.370 to 444.062 cm2. At 60 and 90 days DAP, the varieties Kufri Jyoti (401.642 $cm^{2)}$ and (444.062 cm^2) had the highest leaf area per plant. When the plants were treated with PILATUS (B1) biostimulant, the maximum leaf area per plant was 395.884 cm2 at 60 DAP and 444.017 cm2 at 90 DAP. The lowest leaf area per plant was seen when plants were treated with gold star biostimulant at 60 and 90 DAP, respectively. Similar findings were also reported by Murashev *et al*. (2020) [5].

Yield attributing characters

Regarding biostimulant, the minimum days to marketable harvest 93.299 was obtained from the Pilatus biostimulant**.** Amongst the six different varieties, the minimum days to marketable harvest 83.923 and maximum days to marketable harvest 109.060were obtained from the variety kufri khyati and kufri himalini respectively. The maximum value of tuber diameter (cm) (6.499 cm) highest number of tubers per plant (16.66), Yield per plant (1.075 kg) were found from the application of Pilatus biostimulant. Amongst the six different varieties, kufri khyati produced the maximum value of tuber diameter (cm) (6.667 cm), highest number of tubers per plant (19.437), Yield per plant (1.303 kg). Different growing media on dry matter of tuber (%) was found significant and the highest dry matter of tuber of 17.801% was obtained when Pilatus is used as biostimulant. Amongst the six different varieties, the maximum dry matter of tuber of 22.360% was obtained from the variety kufri Chandramukhi. The amount of tubers per plant difference could be attributed to the cultivars' varied genetic potential. Ghazvini *et al*. (2007) [1] observed that due to increased oxygen levels in the root system, plants develop up to two times quicker and yield more in soilless media containing perlite and zeolite than in standard soil farming methods.

Quality attributing characters

Total sugar (%) with respect to different growing media influenced significantly and the highest total sugar of 0.535% and also reducing sugar (%) 0.389% was observed from application of gold star biostimulant. The six different varieties also varied significantly for the total sugar and reducing sugar. It was found that variety Kufri pokhraj content the maximum value of 0.777% of total sugar (%) and 0.512% of reducing sugar (%). The maximum total soluble solids (5.455˚Brix) was obtained from the application of gold star biostimulant. Amongst the six different varieties, the maximum total soluble solids (7.115˚Brix) was obtained from variety Kufri Jyoti.

Table 1: Effect of different varieties of potato and biostimulant on Growth attributing characters

Treatments	Plant height (cm)		No. of Leaves /plant		leaf area plant^{-1} (cm^2)		No. of halums /plant	
Varieties	**60**	**90**	**60**	**90**	**60**	**90**	**60**	**90**
Kufri Jyoti	57.323	59.275	36.448	54.993	401.642	444.062	3.617	5.497
Kufri Chandramukhi	57.350	59.970	38.625	57.613	331.215	369.370	3.683	5.662
Kufri Himalini	56.182	58.243	43.407	72.850	360.943	406.748	4.765	6.968
Kufri Gaurav	45.675	49.327	48.243	69.320	388.035	426.867	3.563	4.863
Kufri Khyati	58.170	61.233	37.463	56.677	346.158	415.223	4.138	5.972
Kufri Pokhraj	57.885	60.132	36.277	57.817	382.347	402.997	3.010	4.832
Sem+	0.160	0.166	0.111	0.202	0.900	1.645	0.036	0.065
CD@5%	0.472	0.489	0.327	0.598	2.657	4.857	0.106	0.191
Biostimulants								
Pilatus	57.316	59.445	41.260	63.807	395.884	444.017	4.266	6.268
Gold star	53.546	56.282	38.894	61.446	340.896	377.738	3.326	4.996
Sem+	0.092	0.096	0.064	0.117	0.905	0.905	0.021	0.037
CD @ 5%	0.273	0.282	0.189	0.345	2.804	2.804	0.061	0.110

Table 2: Effect of different varieties of potato and biostimulant on Yield attributing characters

Treatments	Days required to marketable Harvesting	No. of tubers	Tuber diameters (cm)	Tuber Yield per plant (kg)	Tuber Dry matter (%)
Varieties					
Kufri Jyoti	100.435	15.220	6.357	0.897	16.955
Kufri Chandramukhi	88.461	14.222	6.041	0.692	17.86
Kufri Himalini	109.060	13.138	5.688	0.634	17.467
Kufri Gaurav	101.610	12.088	5.292	0.603	14.28
Kufri Khyati	83.923	19.437	6.667	1.303	15.383
Kufri Pokhraj	91.078	17.050	6.596	1.134	15.347
Sem+	0.154	0.209	0.035	0.209	0.035
CD@5%	0.453	0.617	0.102	0.617	0.103
Biostimulant					
Pilatus	93.299	16.666	6.499	1.075	16.801
Gold star	98.224	13.719	5.714	0.680	15.629
Sem+	0.089	0.121	0.020	0.121	0.020
CD@5%	0.262	0.356	0.059	0.356	0.059

Table 3: Effect of different varieties of potato and biostimulant on Quality attributing characters

Treatments	Total sugar (%)	Reducing sugar (%)	Total soluble solids (○brix)
Varieties			
Kufri Jyoti	0.455	0.417	7.115
Kufri Chandramukhi	0.313	0.253	5.150
Kufri Himalini	0.427	0.30	4.230
Kufri Gaurav	0.388	0.325	5.622
Kufri Khyati	0.538	0.282	4.605
Kufri Pokhraj	0.777	0.512	4.082
Sem+	0.009	0.011	0.055
CD@5%	0.028	0.032	0.161
Biostimulants			
Pilatus	0.431	0.307	4.813
Gold star	0.535	0.389	5.455
Sem+	0.005	0.006	0.031
CD@5%	0.016	0.018	0.093

Conclusion

From the present investigation it may be concluded that the adoption of soilless technology for cultivation of potato for boosting the yield of the plants may be the good option. The findings of the present research suggested that out of six varieties kufri khyati may be considered suitable variety in soilless culture which performs well comparison to other varieties. In case of biostimulant it may be recommended that the application of Pilatus is the best for growth and yield attributing characters whereas gold star was found effective for quality traits. Overall it concluded that variety kufri khyati in application of Pilatus was best combination for cultivation of potato under soilless culture systems.

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