International Journal of Agriculture Sciences
ISSN: 0975-3710&E-ISSN: 0975-9107, Volume 9, Issue 27, 2017, pp.-4349-4352.
Available online at http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

EFFECT OF PHOTOPERIOD AND DIFFERENT GROWTH SUBSTANCES ON MICROTUBER PRODUCTION OF POTATO (*Solanum tuberosum* L.)

MACWAN S.J.[1*], VAISHNAV P.R. [2], UPADHYAY N.V.[3] AND SHUKLA Y.M.[4]

[1]Department of Plant Physiology. B.A. College of Agriculture, Anand Agricultural University, Anand 388 110
[2]Department of Agril. Statistics, B.A. College of Agriculture, Anand Agricultural University, Anand 388 110
[3]Main Vegetable Research Station, Anand, Anand Agricultural University, Anand 388 110
[4]College of Agriculture and Polytechnique, Vaso, Anand Agricultural University, 387380
*Corresponding Author: Email-sjmacwan@aau.in

Received: May 12, 2017; Revised: May 22, 2017; Accepted: May 23, 2017; Published: June 12, 2017

Abstract- Potato *(Soalnum tuberosum* L.) is one of the most important food crop in the world. The microtuber production in different *in vitro* culture conditions of photo-period and temperature was studied and light conditions of 16 hrs. photoperiod was found to be best. Kufri Chipsona-1 variety found to produce maximum size and weight of micro-tubers in the medium of MS + 5 mgl^{-1} BA + 250 mgl^{-1} CCC. The higher concentration of growth retardants (500mgl^{-1} CCC) found to be less effective comparatively.

Keywords- Photoperiod, Growth Substances, Microtuber, *in vitro*, *Solanum tuberosum*.

Citation: Macwan S.J., et al., (2017) Effect of Photoperiod and Different Growth Substances on Microtuber Production of Potato (*Solanum tuberosum* L.). International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 9, Issue 27, pp.-4349-4352.

Copyright: Copyright©2017 **:** Macwan S.J., et al., This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.

Introduction

Potato is a short day plant, cool season crop and C_3 plant. It is propagated by vegetative and sexually methods. In tropics, potatoes are harvested about 4 months after planting which results in higher yields, as compared to temperate climates, where the main crop growing season can extend upto 6 months. Potato *(Soalnum tuberosum* L.) is one of the most important food crop which contributing to food and nutrition security in the world. Potato tuberization is characterized by anatomical modifications, hormone and physiological changes. The use of *in vitro* growth of plants for production of microtuber has the advantage of higher control of the different factors that might affect the tuber formation compared to plants grown in soil [1]. Growth regulators and photoperiod influence potato tuberization were studied by Hussey and Stacey[2] ,Villafranca et al. [3] and Silva et al.[4]. Cytokinins play an important role in creating the sink during plant development, and through regulating the expression of a gene involved in the partition of assimilates towards the stolons as observed in potato [5].The present study was carried out to examine the microtuber production in three cutivar of middle Gujarat under different photoperiod ,temperature and growth regulators.

Materials and Methods:

In-vitro cultures of *Solanum tuberosum*L cultivars *viz.,* Kufri Chipsona-1, Kufri Badshah and Kufri Pukhraj were used in the experiment. The axenic cultures were established on agar solidified (0.8%) Murashige and Skoog's medium [6] and *In vitro* cultures were multiplied for further experiment by Macwan *et al* [7]. Six to eight weeks old plantlets were sub-cultured aseptically using single nodal segments and incubated under different culture conditions for microtuberisation as given below,

The tuberisation media and different photoperiod treatments were used are as under,

L_1 = MS + 5 mgl^{-1} BA + 250 mgl^{-1} CCC + 8% Sucrose + 0.8% Agar
L_2 = MS+ 10 mgl^{-1} BA + 250 mgl^{-1} CCC + 8% Sucrose + 0.8% Agar
L_3 = MS+ 5 mgl^{-1} BA + 500 mgl^{-1} CCC + 8% Sucrose + 0.8% Agar
L_4 = MS+ 10 mgl^{-1} BA + 500 mgl^{-1} CCC + 8% Sucrose + 0.8% Agar
P_1 = The cultures maintained under short photoperiod. 10 hrs. of light and low temperature 20 ºC during day night.
P_2 = The cultures maintained under long days (16 hrs. of light) with low temperature 20 ºC during day night.
P_3 = The cultures maintained under continuous darkness with low temperature of 20 ºC.

Result and Discussion

Effect of photoperiod on microtuber production

Effect of photoperiod and different growth substances on microtuber production was studied and f results were carried out. The result [Fig-1, 2 and 3] shows the effects during different stages of microtuberisation.

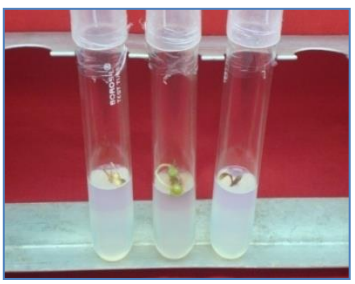

Fig-1 Photoperiod and temperature effect on microtuber formation, during initial stage

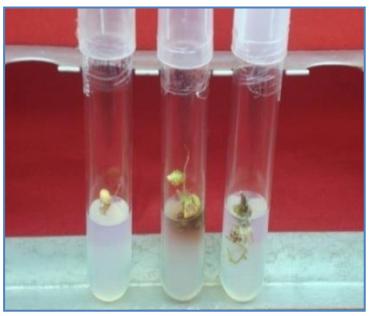

Fig-2 Photoperiod and temperature effect on microtuber formation during development stage

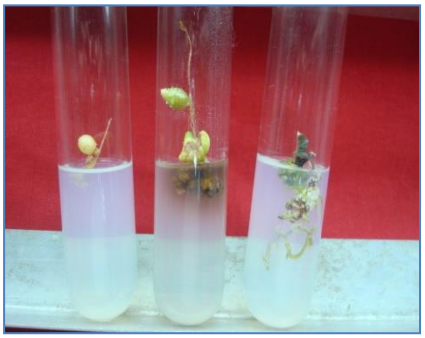

Fig-3 Photoperiod and temperature effect on microtuber formation during maturation stage

Weight of microtuber:

The Kufri Chipsona-1 is significantly higher in weight of microtuber while other two varieties Kufri Pukhraj and Kufri Badshah were found to be at par in weight of microtuber. Different light conditions and the different media treatment were also reported significant results.

P_2 treatment found to be best for obtaining higher weight of microtuber. L_1 treatment (containing 5 mgl^{-1} BA + 250 mgl^{-1}CCC + 8% sucrose) has maximum weight of microtuber followed by the L_3 treatment which contains MS + 5 mgl^{-1} BA + 500 mgl^{-1} CCC + 8% sucrose). Higher levels of BA (10 mgl^{-1}) with higher levels of growth retardants 500 mgl^{-1} CCC gave least response in weight of microtuber (L_4 treatment).

It was noted that the growth retardant levels was kept constant and the levels of cytokinin was increased than high levels of BA (10 mgl^{-1}) decreased the weight of microtuber. Lower levels 5 mgl^{-1} BA has positive effect on weight of microtuber. The [Table-1] denotes that the photoperiod P_2 has significantly higher weight of microtuber followed by P_3 and P_1. Kufri Chipsona-1 has the highest weight of microtuber followed by Kufri Pukhraj and Kufri Badshah in L_1 treatment. The lowest weight of microtuber was reported in L_4 treatment where both BA and CCC higher levels was used.

Same way the photoperiod P_2 gave highest weight (0.203gm) of microtuber followed by P_1(0.149gm) and treatment P_3 (0.124gm) in L_1 media where lower levels of BA (5 mgl^{-1}) and 250 mgl^{-1} CCC was incorporated. It was also observed that lower level of BA(5 mgl^{-1}) gave higher weight (0.165) of microtuber in P_2 treatment where 500 mgl^{-1} CCC (i.e. L_3 treatment) was added followed by P_3 (0.113gm) and P_1 (0.033gm) treatments. Same trend was observed in L_4 medium treatment but the weight of microtuber was least.

From the interaction table of (V x P x L) best treatment combination is $P_2L_3V_2$ (0.251gm) followed by $P_2L_1V_3$ (0.236gm). Further it was observed that lower level (5mgl^{-1}) of BA with higher level (500mgl^{-1}) of CCC yielded higher weight(0.251gm) of microtuber best in combination of P_2 i.e 16 hrs day length treatment in Kufri Chipsona-1.

The lowest weight of microtuber in P_1L_4 followed by P_3L_4 and P_2L_4 and the overall highest weight of microtuber were recorded in P_2L_1 combination, where V_3 variety had higher weight followed by V_1 Kufri Badshah. So it is concluded that P_2 is best and L_4 gave lower response for the weight of microtuber.

Table-1 *Weight of microtuber (gm) for significant interaction*

Treatment	Variety		
	V_1	V_2	V_3
P_1	0.078	0.063	0.071
P_2	0.108	0.162	0.137
P_3	0.089	0.103	0.077
S.Em. ± (V x P)		0.0049	
C.D.		0.0209	
	V_1	V_2	V_3
L_1	0.148	0.166	0.161
L_2	0.098	0.090	0.081
L_3	0.078	0.137	0.096
L_4	0.043	0.044	0.044
S.Em. ± (V x L)		0.00569	
C.D.		0.0241	
	P_1	P_2	P_3
L_1	0.149	0.203	0.124
L_2	0.083	0.115	0.071
L_3	0.033	0.165	0.113
L_4	0.019	0.059	0.052
S.Em. ± (P x L)		0.00569	
C.D.		0.0139	
	V_1	V_2	V_3
P_1L_1	0.149	0.144	0.154
P_1L_2	0.111	0.071	0.068
P_1L_3	0.036	0.020	0.043
P_1L_4	0.018	0.017	0.021
P_2L_1	0.182	0.191	0.236
P_2L_2	0.110	0.118	0.117
P_2L_3	0.091	0.251	0.154
P_2L_4	0.050	0.088	0.040
P_3L_1	0.114	0.163	0.094
P_3L_2	0.073	0.081	0.059
P_3L_3	0.108	0.141	0.090
P_3L_4	0.062	0.028	0.067
S.Em. ± (V x P x L)		0.00986	
C.D.		0.0418	
C.V. %		19.97	

Size of microtuber

From the [Table-2] it was observed that the varieties were non-significant but the photoperiod and the different media were found to be significant for size of microtuber. Further it was recorded that P_2 gave maximum size (0.53 cm) followed by P_3 (0.48 cm) and P_1 (0.39cm). When different media was compared the L_1 treatment found to be best for obtaining maximum size (0.58 cm) and lowest size (0.32 cm) in L_4 medium.

The interaction between P x L and V x P x L were found to be significant, while V x P and V x L were non-significant. From the [Table-3] P_2L_1 combination found to be higher size (0.62 cm) of microtuber. The lowest combination was P_1L_4 where the size of microtuber is (0.22 cm). The results shows the significant effect in variety and photoperiod, variety and the different medium tested and the interaction between variety and both light and photoperiod.

From the results V x P x L maximum size of microtuber in P_2L_1 followed by P_2L_3 where recorded and the lowest microtuber size in P_1L_4. It was observed that the lower levels of BA with 250 mgl^{-1} CCC had maximum size of microtuber. The photographs [Fig-4] shows the effect of different mediain three different photoperiod while [Fig-5] reflects the effect of photoper iod in which 1st and 3rd media shows better results.

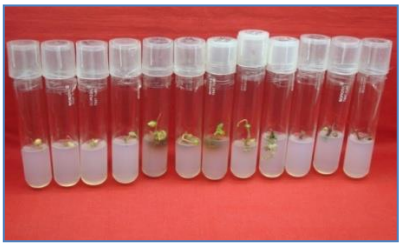

Fig-4 Effect of different media in three duration of photoperiod L_1 L_2 L_3 L_4 and P3, P2, P1

Fig-5 Effect of photoperiod in different media L_1 L_2 L_3 L_4 and P3, P2, P1

Table-2 *Effect of photoperiod and growth substances on microtuber production in different cultivar of potato*

Treatment	Weight of microtuber (gm)	Size of microtuber (cm)
V_1	0.09	0.47
V_2	0.11	0.47
V_3	0.10	0.46
S.Em. ±	0.003	0.014
C.D.	0.012	NS
P_1	0.07	0.39
P_2	0.19	0.53
P_3	0.09	0.48
S.Em. ±	0.003	0.0105
C.D.	0.012	0.028
L_1	0.16	0.58
L_2	0.09	0.49
L_3	0.10	0.49
L_4	0.04	0.32
S.Em. ±	0.033	0.012
C.D.	0.014	0.032
Significant interaction		
V x P S.Em. ±	0.0049	0.0181
C.D.	0.0209	NS
V x L S.Em. ±	0.0057	0.0290
C.D.	0.0241	NS
P x L S.Em. ±	0.0057	0.0209
C.D.	0.01395	0.0324
V x P x L S.Em. ±	0.0099	0.0362
C.D.	0.042	0.0973
C.V. %	19.9	15.4

Table-3 *Size of microtuber (cm) for significant interaction*

Treatment	Variety		
	P_1	P_2	P_3
L_1	0.57	0.62	0.54
L_2	0.45	0.54	0.47
L_3	0.33	0.59	0.54
L_4	0.22	0.36	0.38
S.Em. ± (P x L)		0.0209	
C.D.		0.0324	
P_1L_1	0.55	0.57	0.60
P_1L_2	0.47	0.47	0.41
P_1L_3	0.32	0.32	0.35
P_1L_4	0.21	0.19	0.27
P_2L_1	0.63	0.58	0.64
P_2L_2	0.54	0.52	0.58
P_2L_3	0.57	0.62	0.59
P_2L_4	0.41	0.41	0.26
P_3L_1	0.53	0.60	0.49
P_3L_2	0.44	0.52	0.45
P_3L_3	0.52	0.59	0.52
P_3L_4	0.42	0.30	0.43
S.Em. ±		0.0362	
C.D.		0.0873	
C.V. %		15.4	

From the above discussion it was concluded that Kufri Chipsona-1 found to be higher in weight and size. Light conditions of 16 hrs. photoperiod was found to be best. Further, results revealed that lower level of cytokinin BA (5 mgl^{-1}) in treatment (L_1) with lower level of CCC (250 mgl^{-1}) had higher weight(0.16gm) and size (0.58cm) of the microtuber as compared to higher level of BA (10 mgl^{-1}) in treatment (L_2). When higher level of CCC (500 mgl^{-1}) were tested it was less effective. The microtuber fresh weights of some cultivar were increased in the light compared with continuous dark was reported [8,9].

As such there are varied statements on photoperiod requirement for microtuber production. As the tuberisation occurs in darkness in nature, it may be assumed that tuber induction could be better in darkness, but Lawrence and Barkar [10] found better in short photoperiod.

Wattimena [11] repoeted that the longer the photoperiod, better the tuberisation. Garner and Blake [12] also reported reported that a period of 16hrs days followed by 8 hrs photoperiod gave most rapid development of microtuber.

Light condition produce higher microtuber weight than dark. Light caused greening of microtuber resulted in tuber weight was reported by Hossain, [13]. Probably light enhanced starch gradual accumulation in a more compact form than that in lower light or dark conditions. The results in respected of weight and size of microtuber obtained in our findings were also reported earlier [14-16].

Randhawa and Chandra [17] obtained much higher weight in MS + 10 mg^{-1} BA + 8 % sucrose, while Hossain [13] obtained higher weight in 5 mg^{-1} BA instead of 10 mg^{-1} BA, which is conformity in our results. Probably, varietal difference and their response are the main reasons for such a performance.

Koda and Okayawa,[18] indicated that the contradictory results among different scientists may be due to the differential requirement of growth regulators and other factors for microtuber induction and subsequent microtuber growth. Thus, it is concluded that depending upon the requirement, protocols need to be optimized for different cultivar as well as different characters also. Same conclusion made other scientist [18-20].

Conclusion

When microtuber production was compared under different *in vitro* conditions of photoperiod and lower level of temperature it was concluded that Kufri Chipsona-1 produced microtubers higher in weight and size.Light conditions of 16 hrs. photoperiod was found to be best with 20 °C temperature. Light conditions produce higher microtuber weight than dark, light caused greening of microtuber.

Acknowledgement: First author would like to express his thanks to Dr. A.R. Mehta, Emeritus Scientist (CSIR, New Delhi) for his valuable suggestions, remarks and his statements a lot to build up confidence to achieve a goal. Special thanks to Dr. D.C. Joshi Dean & Principal, FPT and Mr. V.P.Macwan for their advice and moral support.

Author Contributions: All author equally contributed

Abbreviations

MS- Murashige and Skoog, BA- 6-Benzylaminopurine, benzyl adenine, CCC-Chlorocholine Chloride, V- variety, M-media, gm-gram, mg- milligram, ml-milliliters, cm- centimetre,

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

Conflict of Interest: None declared

References

[1] Veramendi J., Willmitzer L. and Trethewey R.N. (1999) *Plant Phys. Biochem*., 37, 693-697.
[2] Hussey G. and Stacey N. (1984) *Ann. Bot*., 53, 565-578.
[3] Villafranca M.J., Veramendi J., Sota V. and Mingo-Castel A.M. (1998). *Plant Cell Rep*., 17, 787-790.
[4] Silva J.A.B., Otoni W.C., Martinez C.A., Dias L.M. and Silva MAP (2001) *Sci. Horticult*., 89, 91-101.
[5] Prat S. (2004) Hormonal and daylength control of potato tuberization. In PJ

Davis (ed). Plant Hormones: Biosynthesis, Signal Transduction, Action. Kluwer Acad. Publ. Dordrecht, Netherlands. pp. 538-560
[6] Murashige T. and Skoog F. (1962) *Physiol.Plant*, 15, 473-497.
[7] Macwan S.J., Subhash N., Vaishnav P.R. and Shukla Y.M. (2010) In National conference of plant physiology and molecular approaches for crop improvement under changing environment, November 25-27, BHU, Varasani, pp173.
[8] Slimmon T., Souza M.V. and Coffin R. (1989).*Am. Potato J,* .66, 843–848.
[9] Gopal J., Minocha J.L. and Gosal S.S. (1998) *J. Ind. Potato Assoc*., 25, 119–124
[10] Lawrence C.W. and Barker W.G. (1963) *Amer. Pot. J.,* 40, 349-356
[11] Wattimena G.A. (1983) Micropropagation as an alternative technology for potato production in Indonesia. Ph.D. Thesis, University of Wisconsin, Madison
[12] Garner N. and Blake I. (1989) *Ann. Bot.,* 63, 663-674.
[13] Hossain M.J. (2005) *Plant Tissue Cult. & Biotech.*, 15(2), 157-166.
[14] Simko I. (1990) *Biologia (Bratislava)*, 46, 251-256.
[15] Hossain M.J. and Sultana N. (1998) *Bangladesh. J. Agril. Res*., 23, 685-690.
[16] Yeasmin L. (2005) Production of microtubers in potato (*Solanum tuberosum* L.) MS thesis, Department of Biotechnology, Bangladesh Agricultural University, Mymensingh. pp. 1-81.
[17] Randhawa G.J. and Chandra R. (1990) .*J. Indian Pot. Assoc.,* 17, 199-201.
[18] Koda Y. and Okayawa Y. (1983) *Jap. J. Crop Sci*., 52, 592-597.
[19] Gopal J., Minocha J.L. and Dhaliwal H.S. (1998) *Plant Cell Reports*, 17, 794-798.
[20] Gopal J. Chamail A. and Sarkar D. (2004) *In-vitro Cellular Development Biology Plant*, 40(5), 485-490.