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Studies on effect of growth regulators and extended photoperiod on growth and flowering in potato (*Solanum tuberosum*)

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Abstract
Potato is commonly propagated through tubers. For raising of potato in one hectare of land, we require 15-20 tons of seed tubers. To overcome the problem of high cost of the seed tubers, long distance transportation, storage of bulky material etc. use of botanical seed is a viable option by induction of flowering using growth regulators, extended photoperiod etc. With this objective in view, an experiment was carried out to investigate the effect of different plant growth regulators on vegetative growth and flowering in potato under natural as well as extended photoperiod in coastal Andhra Pradesh. Four growth regulators *viz.* gibberellic acid (GA_3), silver thiosulphate (STS), indole-3-butyric acid (IBA), 2,4-dichlorophenoxyacetic acid(2,4-D)and water as control were sprayed on five heat tolerant genotypes *viz.*, Kufri Surya, HT/10-1554, HT/12-116, HT/12-834 and HT/16-113 under natural and extended photoperiod. Results revealed that flowering response varied with genotype, photoperiod and growth regulator with interaction effects. The genotypes HT/12-1554 and HT/12-834 flowered both under natural as well as extended photoperiod in response to some of the growth regulators. HT/16-113 flowered only under extended photoperiod in response to GA_3@ 50 ppm. Kufri Surya and HT/12-116 did not flower under any treatment.GA_3 @50 ppm and STS @ 2.0 mM were found to be more effective in inducing flowering than IBA @ 10 ppm and 2,4-D @ 50 ppm. Response of the genotypes and effect of growth regulators enhanced under extended photoperiod.

Keywords: Studies, regulators, extended, flowering, *Solanum tuberosum* L.

Introduction
Potato (*Solanum tuberosum* L.) is highly nutritious, easily digestible, wholesome food containing carbohydrates, proteins, minerals, vitamins and high-quality dietary fibre. Potato is world's major non-cereal food crop after rice, wheat and maize. It belongs to the family Solanaceae. Commonly cultivated potato is tetraploid (2n=4X=48). *Solanum tuberosum* includes two subspecies *viz*., *ssp. tuberosum* adapted to long days and *ssp. andigena* adapted to short days. Traditionally commercial production of potatoes has been based on the use of seed tuber for planting. Cost of seed tubers account for 40-50% of total cost of cultivation which hinders extension potato cultivation to non-traditional areas. Use of botanical seed also known as true potato seed (TPS) is a viable alternative. The cultivated potato is a long-day (>16 h) plant for flowering and short-day plant for tuber formation (Markarov, 2002) [10]. Potato requires long days, (14-18 h), abundant humidity, and moderate night temperature (15-20°C) for flower induction (Almekinders and Struik, 1996) [1]. In India, hybridization programme is being carried out at Kufri (2500 MSL) in Himachal Pradesh where such conditions prevail during summer season. Efforts have been made with success, for the purpose of varietal development, to induce flowering in potato in sub tropical North Indian plains during winters (short days) where the commercial crop is largely grown. Flowering could be induced in 28 non- flowering potato genotypes under short days of north central plains through artificially extended photoperiod supplemented with hormonal combination of gibberellic acid (50 ppm) + indole butyric acid (10 ppm) + kinetin (2 ppm) (Luthra and Khan, 2000) [9]. Silver thiosulphate (STS) application in combination with photoperiod extension successfully induced flowering in non-flowering potato genotypes under short day conditions in Punjab (Kumar *et al.*, 2006 and Sharma *et al.* 2016). Induction of flowering in potato in tropical areas through different means will pave the way for development of true potato seed (TPS) for commercial propagation of the crop.

Keeping the above in view the present investigation was undertaken to induce flowering in different potato genotypes through extended photoperiod and application of growth regulators.

Materials and Methods

The study was conducted at, College of Horticulture, Dr. Y. S. R Horticultural University, Venkatarammannagudem, West Godavari district, Andhra Pradesh. The location of the experimental field fall under agro climatic zone -10, humid, east coast plain and hills (Krishna –Godavari zone) with an averagerain fall of 900 mm at an altitude of 34m (112 feet) above mean sea level. The experimental site was geographically situated at 16^0 N and 81^0 E longitude. The site experiences hot humid summers and mild winters. The experiment was laid out in 2 Factorial Randomized Block Design(FRBD) during winter of 2020-21withfive heat tolerant potato genotypes procured from Central Potato Research Institute Campus, Modipuram, Meerut *viz*., HT/10-1554, HT/12-116, HT/12-834, HT/16-113 and Kufri Surya, each grown in a plot of 4.5 m × 1.2 m with 30 plants spaced at 60 x 30 cm in two replications. One such set of genotypes were grown under natural short days and another set was grown under extended photoperiod provided through artificial illumination with four LED lamps of 36 watts each from 6.00 PM to 4.00AM. Four growth regulators *viz*., GA_3 @ 50 ppm, STS @ 2.0 mM, IBA @ 10 ppm,2-4-D @ 50 ppm and water as control were sprayed from 30 DAP at weekly intervals up to 60 days on both the sets. Data on growth and flowering were collected from five randomly selected plants form each treatment in each genotype.

Results and Discussion

Plant height

It was found that(table.1), the genotype HT/12-834 recorded highest plant height (cm)at 60DAP both under natural photoperiod as well as extended photoperiod (47.06 cm and 49.74 respectively). The values are significantly higher than those of check variety Kufri Surya under both conditions. Other three genotypes are on par with Kufri Surya for this trait under both conditions. And the lowest values were recorded by the genotype HT/12-1554 (33.4 cm and 36.44 cm respectively). Among the chemical treatments, GA_3 @ 50 ppm recorded the highest plant height both under natural as well as extended photoperiod (43.74 cm and 46.33 respectively). Amoung the other three chemicals, IBA @ 10 ppm and 2,4-D @ 50ppmproduced significantly higher values than the control *i.e*. water spray under both conditions. While the effect of STS @ 2.0mM was found to be on par with the control. All the genotypes and all the chemical treatment recorded higher plant height under extended photoperiod when compared to natural photoperiod. However, the interaction effect of genotypes and chemicals was found non-significant. The highest plant height in GA_3 treated plants might be due to inter nodal elongation. It is known that GA_3 has stimulatory effect on plant growth by cell elongation and rapid cell division in apical parts of plant and it is responsible for preventing genetic dwarfism (Davis *et al*., 1991) [4].

Table 1: Effect of growth regulators and photoperiod on plant height in potato

S. No	Genotype	Plant height (cm) at 60 DAP											
		Natural photoperiod						Extended photoperiod					
		GA_3	STS	IBA	2,4 D	Water	Mean	GA_3	STS	IBA	2,4 D	Water	Mean
1	HT/12-1554	37.50	31.56	35.00	33.25	29.72	33.41	40.16	34.52	38.72	36.26	32.56	36.44
2	HT/12-116	42.65	36.12	40.58	38.50	34.56	38.43	45.26	38.85	42.87	41.20	37.20	41.08
3	HT/12-834	51.50	44.56	49.95	47.00	42.27	47.06	53.96	47.12	52.56	49.87	45.18	49.74
4	HT/16-113	41.25	34.42	39.35	36.95	33.45	37.08	43.52	36.97	42.18	40.15	36.12	39.79
5	Kufri Surya	45.80	39.75	43.85	41.75	37.95	41.82	48.75	42.68	46.12	44.54	41.00	44.62
	Mean	43.74	37.28	41.75	39.49	35.59	39.56	46.33	40.03	44.49	42.40	38.41	42.33

	Natural photoperiod			Extended photoperiod		
	G	C	GXC	G	C	GXC
S.Em±	0.680	0.680	1.522	0.913	0.913	2.041
CD (P = 0.05)	1.986	1.986	NS	2.664	2.664	NS

Plant spread: It was found that (table.2), the genotype HT/12-834 recorded highest value for plant spread (cm)at 60DAP both under natural as well as extended photoperiod (53.46 cm and 55.74cm respectively) and is significantly superior than the check variety Kufri Surya. The genotypes HT-12-1554 and HT/12-116 were found to be on par with Kufri Surya in both photoperiods, where as HT/16-113 recorded significantly lower plant spread than Kufri Surya under both the photoperiods. Among the chemical treatments, GA_3 @50 ppm recorded the highest plant spread in both photoperiods (51.68 and 53.89 respectively) and is significantly superior than control. IBA @10 ppm and 2,4-D @ 50ppm applications also produced significantly higher plant spread under natural as well as extended photoperiod. Where the affect of STS @ 2mM was found to be on par with that of control in both photoperiods. However, the interaction effect of genotypes and chemicals was found non-significant in both photoperiods. These results are in agreement with those of Rathod *et al.* (2015) [6] with application of GA_3at 200 ppm in okra and of Demagane *et al.* (1987) in French bean.

Table 2: Effect of growth regulators and photoperiod on plant spread in potato

S. No	Genotype	Plant spread (cm) at 60 DAP											
		Natural photoperiod						Extended photoperiod					
		GA_3	STS	IBA	2,4 D	Water	Mean	GA_3	STS	IBA	2,4 D	Water	Mean
1	HT/12-1554	49.33	45.20	46.85	46.01	44.50	46.38	51.65	47.75	49.55	48.69	46.97	48.92
2	HT/12-116	54.01	48.01	51.25	49.75	46.55	49.91	56.84	50.48	53.90	52.43	49.02	52.53
3	HT/12-834	57.82	51.62	54.12	53.95	49.79	53.46	59.81	54.12	56.82	55.70	52.26	55.74
4	HT/16-113	44.90	39.70	42.35	42.15	38.20	41.46	47.64	42.20	45.05	44.83	41.77	44.30
5	Kufri Surya	52.35	46.52	49.80	48.98	45.05	48.54	53.50	48.02	52.00	51.66	46.25	50.29
	Mean	51.68	46.21	48.87	48.17	44.82	47.95	53.89	48.51	51.46	50.66	47.25	50.36

	Natural photoperiod			Extended photoperiod		
	G	C	GXC	G	C	GXC
S.Em±	1.12	1.12	2.50	1.06	1.06	2.38
CD (P = 0.05)	3.26	3.26	NS	3.11	3.11	NS

Number of shoots

The mean number of shoots under different chemical treatments was highest in the genotype HT/12-116 (table.3) in both natural and extended photoperiods (5.80 and 6.06) and the values are significantly superior than those of check variety Kufri Surya. While the mean number of shoots produced by genotype HT/12-834 are found to be on par with Kufri Surya in both extended and natural photoperiods (3.10 and 3.16 respectively). HT/12-1554 and HT/16-113 produced significantly fewer shoots than the check variety under both photoperiods. The number of shoots per plant is more under extended photoperiod compared to natural photoperiod.However, the interaction effect of genotypes and chemicals was found non-significant in both photoperiods. These findings are in conformity with Abebe *et al.* (2019) [2] and Ravi Shenkar *et al.* (2016) [7].

Table 3: Effect of growth regulators and photoperiod on number of shoots/plant in potato

S. No	Genotype	Number of shoots at 60 DAP											
		Natural photoperiod						Extended photoperiod					
		GA_3	STS	IBA	2,4 D	Water	Mean	GA_3	STS	IBA	2,4 D	Water	Mean
1	HT/12-1554	1.40	1.30	1.60	1.50	1.00	1.36	3.00	2.20	2.70	2.90	2.30	2.62
2	HT/12-116	6.00	5.50	5.80	5.30	6.40	5.80	6.00	6.50	5.80	6.00	6.00	6.06
3	HT/12-834	3.50	3.30	3.20	3.30	2.20	3.10	3.71	3.10	3.90	3.40	2.70	3.36
4	HT/16-113	1.80	2.90	1.70	2.20	1.80	2.08	1.90	2.40	2.30	2.00	1.90	2.10
5	Kufri Surya	3.30	3.20	3.00	2.80	2.45	2.95	4.00	2.80	3.70	2.70	2.60	3.16
	Mean	3.20	3.24	3.06	3.02	2.77		3.72	3.40	3.68	3.40	3.10	

	Natural photoperiod			Extended photoperiod		
	G	C	GXC	G	C	GXC
S.Em±	0.21	0.21	0.47	0.16	0.16	0.36
CD (P = 0.05)	0.61	NS	NS	0.47	NS	NS

Inflorescence Length: Under natural photoperiod, emergence of inflorescence was observed only in two potato genotypes*i.e.*HT/12-1554 and HT/12-834) under two chemical sprays (GA_3 and STS). Other three genotypes *viz.*, HT/12-116, HT/16-113 and Kufri Surya did not flower under any chemical treatment. Under extended photoperiod, in addition to the above two lines, HT/16-113 also flowered under GA_3 treatment.Under natural photoperiod, the genotype HT/12-1554 flowered only under two chemical treatments *i.e.* GA_3 and STS where as it flowered under all the chemical treatments including control (water spray) under extended photoperiod. It was also observed that, the mean length of the inflorescence was higher under extended photoperiod compared to that under natural photoperiod. Statistically significant differences were found with respect to inflorescence length among genotypes, chemicals and their interactions. These observations indicate that flowering in potato is greatly influenced by environmental conditions, external hormonal treatments in addition to the inherent genetic differences amount the genotypes.

Table 4.: Effect of growth regulators and photoperiod on inflorescence length in potato

S. No	Genotype	Inflorescence length (cm)											
		Natural photoperiod						Extended photoperiod					
		GA_3	STS	IBA	2,4 D	Water	Mean	GA_3	STS	IBA	2,4 D	Water	Mean
1	HT/12-1554	13.35	13.10	0.00	0.00	0.00	5.29	15.22	13.25	13.72	14.12	12.75	13.81
2	HT/12-116	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	HT/12-834	13.00	12.20	0.00	0.00	0.00	5.04	14.20	13.10	0.00	0.00	0.00	5.46
4	HT/16-113	0.00	0.00	0.00	0.00	0.00	0.00	11.50	0.00	0.00	0.00	0.00	2.30
5	Kufri Surya	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean	5.27	5.06	0.00	0.00	0.00		8.18	5.27	2.74	2.82	2.55	

	Natural photoperiod			Extended photoperiod		
	G	C	GXC	G	C	GXC
S.Em±	0.07	0.07	0.17	0.10	0.10	0.24
CD (P = 0.05)	0.22	0.22	0.49	0.31	0.31	0.71

Number of flower buds per plant: Of the five genotypes studied (table.5), only two genotypes, HT/12-1554 and HT/12-834 produced flower buds under natural photoperiod on application of growth hormones $GA_3$and STS.
Other three genotypes *viz*. HT/12-116, HT/16-113 and Kufri Surya did not flower under natural photoperiod under any chemical treatment. However, under extended photoperiod, in addition to the above two lines another genotype HT/16-113 also produced flower buds on GA_3 application. The genotype HT/12-1554 produced flower buds under extended photoperiod under all chemical treatments including water spray. The mean number of flower buds was also highest in the genotype HT/12-1554 under both photoperiods under all the chemical treatments. The mean number of flower buds in different genotypes and treatment is higher under extended photoperiod. Statistically significant differences were found with respect to number of flower buds per plant among genotypes, chemicals and their interactions.

Table 5: Effect of growth regulators and photoperiod on number of flower buds in potato

S. No	Genotype	Number of flower buds											
		Natural photoperiod						Extended photoperiod					
		GA_3	STS	IBA	2,4 D	Water	Mean	GA_3	STS	IBA	2,4 D	Water	Mean
1	HT/12-1554	21.92 (4.78)	16.40 (4.17)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	7.66 (2.39)	22.35 (4.83)	19.40 (4.51)	15.60 (4.07)	18.65 (4.43)	14.15 (3.89)	18.03 (4.34)
2	HT/12-116	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.000 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.0 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
3	HT/12-834	17.77 (4.33)	15.60 (4.07)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	6.67 (2.28)	18.31 (4.39)	16.60 (4.19)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	6.98 (2.31)
4	HT/16-113	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	9.50 (3.23)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	1.90 (1.44)
5	Kufri Surya	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
	Mean	7.94 (2.42)	6.40 (2.24)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)		10.03 (2.89)	7.20 (2.34)	3.12 (1.61)	3.73 (1.68)	2.83 (1.57)	

	Natural photoperiod			Extended photoperiod		
	G	C	GXC	G	C	GXC
S.Em±	0.009	0.009	0.021	0.011	0.011	0.024
CD (P = 0.05)	0.027	0.027	0.061	0.032	0.032	0.071

*Values in parenthesis are transformed values

Number of flowers per plant

Of the five genotypes studied (table.6), only two genotypes, HT/12-1554 and HT/12-834 produced flowers under natural photoperiod on application of growth hormones $GA_3$and STS. Other three genotypes *viz*. HT/12-116, HT/16-113 and Kufri Surya did not produce flowers under natural photoperiod under any chemical treatment. However, under extended photoperiod, in addition to the above two lines another genotype HT/16-113 also produced flowers on GA_3 application. The genotype HT/12-1554 produced flowers under extended photoperiod under all chemical treatments including water spray. The mean number of flowers was also highest in the genotype HT/12-1554 under both photoperiods under all the chemical treatments. The mean number of flowers in different genotypes and treatment is higher under extended photoperiod than in natural photoperiod. Statistically significant differences were found with respect to number of flower per plant among genotypes, chemicals and their interactions. Percent flower retention (number of flower buds/ number of flowers x 100) is more in the genotypes sprayed with growth regulators (87 to 93%) compared to control (77%) under extended photoperiod.

Table 6: Effect of growth regulators and photoperiod on number of flowers in potato

S. No	Genotype (G)	Number of flowers											
		Natural photoperiod						Extended photoperiod					
		GA_3	STS	IBA	2,4 D	Water	Mean	GA_3	STS	IBA	2,4 D	Water	Mean
1	HT/12-1554	19.25 (4.50)	14.90 (3.98)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	6.83 (2.29)	21.10 (4.70)	18.40 (4.40)	13.60 (3.82)	16.30 (4.15)	10.9 (3.45)	16.06 (4.10)
2	HT/12-116	0.00 (1.00)	0.00 (1.00)	0.00) (1.00	0.00) (1.00	0.00) (1.00	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
3	HT/12-834	16.40 (4.17)	14.90 (3.98)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	6.26 (2.23)	17.50 (4.30)	14.25 (3.90)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	6.35 (2.24)
4	HT/16-113	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	8.10 (3.01)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	1.62 (1.40)
5	Kufri Surya	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
	Mean	7.13 (2.33)	5.96 (2.19)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)		9.34 (2.80)	6.53 (2.26)	2.72 (1.56)	3.26 (1.63)	2.18 (1.49)	

	Natural photoperiod			Extended photoperiod		
	G	C	GXC	G	C	GXC
S.Em±	0.01	0.01	0.03	0.01	0.01	0.02
CD (P = 0.05)	0.04	0.04	0.09	0.02	0.02	0.06

*Values in parenthesis are transformed values

To sum up, the genotypes Kufri Surya and HT/16-113 did not flower at all under any treatment. While the genotypes HT/12-1554 and HT/12-834 responded well in terms of influence length, number flower buds/plant and number of flowers/plant under different treatments. HT/16-113 responded only to a specific treatment combination. Amount the growth regulators, GA_3 @50 ppm and STS @ 2.0 mM produced better results compared to IBM @ 10 pm and 2,4-D @50 ppm and the flowering response enhanced under extended photoperiod. Similar results of enhanced flowering, increase in flower stalk length *etc*. were reported by Luthra and Khan (2000) [9] under short days of north central plains through artificially extended photoperiod supplemented with hormonal combination of gibberellic acid (50 ppm) + indole butyric acid (10 ppm) + kinetin (2 ppm). Silver thiosulphate (STS) application in combination with photoperiod extension successfully induced flowering in non-flowering potato genotypes under short day conditions in North western plains of Punjab (Sharma *et al.* 2016, Kumar *et al.*, 2006 and Gopal and Rana, 1988) [8]. It is pertinent to mention here that some genotypes did it flower at all in the above mentioned experiments.

Conclusion

Production of abundant fertile flowers is essential for development of new cultivars of potato for improved yields, quality traits and resistance to biotic and abiotic stresses by crossing suitable parents followed by clonal selection. This will also paves the way for development of True Potato Seed (TPS) technology as an alternative to tuber propagation. Flowering in potato is influenced by many factors including genetic make of the line, diurnal temperatures, day length and relative humidity. Potato usually does not flower under short day conditions. It requires long days, moderate to low temperatures and high relative humidity and not all the genotypes respond equally. Flowering can be induced in tropical and subtropical regions by growing responsive genotypes during winters under artificially extended day lengths as well as exogenous application growth regulators.

References

1. Almekinders CJM, Struik PC. Shoot development and flowering in potato (*Solanum tuberosum* L.). Potato Res. 1996a;39:581-607.
2. Abebe Chindi, Tekaligh Tsegwa. effect of Gibberelic acid on growth, yield and Quality of potato (*Solanum tuberosuml*.) in central Highland of Ethiopia. J Hortic. sci. For. 2019;1:205
3. Bodlaender KBA. Influence of temperature, radiation and photoperiod on development and yield. In: J.D. lvins & F. L. Milthorpe (Eds), The growth of the potato. Butterworth, London, 1963, 199-210
4. Davis TD, Curry EA, Steffens GL. Chemical regulations of vegetative growth. Critic. Rev. plant Sci. 1991;10(2):151-188
5. Demagante AL, Vander Zaag P. The response of potato (Solanum spp.) to photoperiod and light intensity under high temperatures. Potato Research. 1988;31:73-83.
6. Rathod RR, Gore RV, Bothikar PA. Effect of growth regulators on growth and yield of french bean (*Phaseolus vulgaris* L.) var. Arka Komal. Journal of Agriculture and Veterinary Science. 2015;8(5):36-39.
7. Ravi Shankar, Dhirendra Singh, Jitendra Kumar. Photoperiod effect on yield attributing traits of potato (*Solanum tuberosum* L.) Research in Environment and Life Sciences ISSN: 0974-4908 Res. Environ. Life Sc. 2016;9(6)771-774.
8. Gopal J, Rana MS. Induction of floweing in potato north-western plains of India j Indian potato assoc. 1998;15:91-93
9. Luthra SK, Khan IA. Induction of flowering in potato under short day conditions. Potato, global research and development. 2000;1:150-15
10. Markarov AM. Causes of flowering of long-day potato species under short-day and cold-night conditions. Russ. J Plant Physiol. 2002;49(4):465-469. https://doi.org/10.1023/A:1016399606792
11. Sharma SP, Sharma D, Dhall RK. Flower induction in potato under short day condition in NW plains of India, 2019.