International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2025): 5.29
IJABR 2025; SP-9(11): 652-655
www.biochemjournal.com
Received: 01-08-2025
Accepted: 05-09-2025

Anil Kumar
District Extension Specialist (Forestry), Krishi Vigyan Kendra, Damla Yamunanagar, Haryana, India

SK Dhanda
Principal Scientist, Department of Forestry, College of Agriculture, CCSHAU, Hisar, Haryana, India

KS Ahlawat
Assistant Scientist (Forestry), Department of Forestry, College of Agriculture, CCSHAU, Hisar, Haryana, India

Hans Raj
Assistant Scientist (Vegetable), Department of Vegetable Science, College of Agriculture, CCSHAU, Hisar, Haryana, India

CS Dagar
Assistant Scientist (Meteorology), Department of Agricultural Meteorology, College of Agriculture, CCSHAU, Hisar, Haryana, India

Suresh Kumar
Assistant Director (Crops), Directorate of Research, CCSHAU, Hisar, Haryana, India

Rajesh Kathwal
Assistant Scientist (Agronomy), Regional Research Station (Horticulture), Buria, Yamunanagar, Haryana, India

Corresponding Author:
Anil Kumar
District Extension Specialist (Forestry), Krishi Vigyan Kendra, Damla Yamunanagar, Haryana, India

Effect of poplar spacing on growth, yield, and physiological parameters of different varieties of potato

Anil Kumar, SK Dhanda, KS Ahlawat, Hans Raj, CS Dagar, Suresh Kumar and Rajesh Kathwal

DOI: https://www.doi.org/10.33545/26174693.2025.v9.i11Si.6297

Abstract

The experiment was carried out during 2021-22 and 2022-23 at research area of Department of Forestry, CCS Haryana Agricultural University, Hisar (20° 10´N latitude, 75°46´ E longitude, altitude 215 m mean sea level), situated in the semi-arid region of North-Western India. The tree species was Poplar (*Populus deltoides* Bartr. ex Marsh) which were planted during February, 2017. There were four planting geometry as 3×3 m, 4×3 m, 5×3 m and 6×3 m and control (sole crop of potato devoid of trees). There were six potato varieties (Kufri Bahar, Kufri Neelkanth, Kufri Lima, Kufri Ganga, Kufri Pushkar and Kufri Pukhraj). The experiment was carried out in Factorial Randomized Block Design with three replications. The results revealed that wider poplar tree spacing S4 (6×3 m) with potato variety V2 (Kufri Neelkanth) produced significantly taller plants at 30 DAS, i.e., 43.00 cm and 43.00 cm during 2021-22 and 2022-23, respectively. At 90 DAS, again poplar tree spacing S3 (5×3 m) with variety V2 (Kufri Neelkanth) produced significantly taller plants, i.e., 66.74 cm during 2021-22 and 65.26 cm during 2022-23. Significantly higher chlorophyll content was recorded under closer spacings of poplar tree S1: 3×3 m with potato variety V3 (Kufri Lima) i.e., 26.92 cm at 30 DAS which was found at par with S2: 4×3 m with potato variety V3 (Kufri Lima) i.e., 26.60 cm during 2021-22. Same results have been obtained during 2022-23. Poplar tree spacing S1: 3×3 m with potato variety V1: Kufri Bahar and V3: Kufri Lima resulted into significantly higher chlorophyll content with soil plant analysis development (SPAD) values (36.97 and 35.87) in potato leaves at 90 DAS during 2021-22. The poplar tree spacing S4: 6×3 m with variety V3: Kufri Lima resulted in significantly higher tuber yield during both the years, i.e., 418.19 and 421.20 q/ha during 2021-22 and 2022-23, respectively. Overall, Kufri Lima was found most suitable variety for potato cultivation under poplar-based agroforestry system with wider spacing of 6×3 m.

Keywords: Agroforestry, chlorophyll content, Kufri Lima, plant height, poplar and tuber yield

Introduction

In agroforestry systems, trees are considered as one of the important natural resources which provide many useful products and services to the society. There is a need of increasing the tree cover to fulfil the needs of industries requiring wood-based raw materials. The area under agroforestry in India is about 25.32 million hectares which can also be extended to much larger area. During the first year under agroforestry, both the components like trees and agricultural crops can provide renumeration without affecting overall income, proved economical and environment friendly [1, 2, 3]. Mixed cropping seems to be equally fit in the agroforestry systems enhancing the crop productivity, soil fertility, farmers income and better resource utilization [4]. The present need is to utilize the natural resources in terms of intercropping within the available space like space available between the tree lines under agroforestry which can both provide food and raw materials for dependent industries [5]. Presently, farmers are keener to grow more trees which are fast growing and multipurpose in nature enabling them to fetch the higher incomes during their utmost requirement when all other field components are under developing stage. Poplar which is scientifically named as *Populus deltoides*, grows fast and propagated vegetatively. The 6-to-8-year poplar trees in a block plantation, can produce 20-25 m^3/ha/year biomass while it produces 2-3 m^3/ha/year biomass produce in boundary plantations [6].

Poplar tree helps to prevent the land degradation for sustainable agriculture production in agroforestry system [7]. It has the capability to fulfil the multifarious requirements of wood-based industries viz. plywood, pulp, matchwood, veneer, light furniture, sports goods, fibreboard, pencil making and packing cases *etc*. [8]. The plywood, board, match, paper and sports industries are mostly dependent on poplar and willows in India as per report on poplars and willows, 2012-15.

Historically, after 1980, poplar tree becomes more popular in Himachal Pradesh, Punjab, Haryana and Uttar Pradesh. In Haryana, the annual turnover is Rs. 450-500 crore from agroforestry and farm forestry activities. The popularity was due to its fast-growing nature, tolerance to pruning, less competition with associated crops resulting in higher economic returns per unit area. It is also well established that poplar-based agroforestry results in higher economic returns as compared to growing crops as sole [9]. The agroforestry system involving poplar tree was found more ecologically sustainable and economically viable as compared to other trees [10, 11]. The deciduous nature of poplar makes it more suitable for crops sown in winter season providing lesser shedding effect and ensure more light penetration for optimum growth of under-storey crops. The popularity of potato (*Solanum tuberosum* L.) can be understood with the fact that it is most consumable vegetable in the world [12]. The genus of potato is *Solanum* related to Solanaceae family, introduced in India in early 17th century which later spread to various parts of the country [13]. In North-West plains of India, it is primarily grown as winter season vegetable crop and fits in poplar-based agroforestry system generating supplementary income and reduce the losses of tree cover to fetch more land for crop cultivation.

Potato provides macro and micro nutrients and thus an essential part of human diet. It is used as vegetable in daily diets and processed products like chips and fries are more favourable. It is used to feed the cattle and chicks. Further, it is also used as seed for sowing in the next season [14]. Small and marginal farmers are opting vegetable cultivation to get high economic returns per unit area and time. Among vegetables, potato is an important crop that fits well under this option and it occupies about half of the total vegetable area in the state. Its cultivation is remunerative and is playing role in diversification of existing cereal-based cropping system [15].

In India, sole cropping system is dominant from a longer period but with the introduction of agroforestry, the land use system got improvised by growing agricultural crops along with trees for all basic components of livelihood like firewood for fuel, timber for home consumption and furniture, fodder for animals and industrial chemicals [16]. The scientific designing of agroforestry systems may result into synergistic effect for environment and crop cultivation inducing competition between crops and trees, which eventually helps to sequester more carbon [17]. The present study is framed to find out the suitable potato variety under poplar-based agroforestry system for optimal growth, physiology and yield.

Materials and Methods

The experiments was carried out during 2021-22 and 2022-23 at research area of Department of Forestry, CCS Haryana Agricultural University, Hisar (20° 10´ N latitude, 75° 46´ E longitude, altitude 215 m mean sea level), situated in the semi-arid region of North-Western India. The tree species was poplar (*Populus deltoides* Bartr. ex Marsh) which were planted during February, 2017. There were four planting geometry as 3×3 m, 4×3 m, 5×3 m and 6×3 m. Control treatment was devoid of tree having only sole crop of potato. There were six varieties of potato as Kufri Bahar, Kufri Neelkanth, Kufri Lima, Kufri Ganga, Kufri Pushkar and Kufri Pukhraj. The experiment was carried out in Factorial Randomized Block Design with three replications. The recommended package of practice of potato of Chaudhary Charan Singh Haryana Agricultural University was followed both in *Populus deltoides* based agroforestry system and control (sole potato crop). The different growth parameters of potato crops were plant height, total tuber yield along with physiological parameter as chlorophyll content (SPAD value).

(i) Total tuber yield (q/ha) = [Tuber weight from net plot (kg)/Net plot area (m^2)] ×10,000÷100

Results and Discussion

Plant height

The data pertaining to plant height have been shown in Table 1. The interaction effects of poplar spacing and varieties were found significant. Wider poplar tree spacing S4 (6×3 m) with potato variety V2 (Kufri Neelkanth) produced significantly taller plants at 30 DAS, i.e., 43.00 cm and 43.00 cm during 2021-22 and 2022-23, respectively. But later on, at 60 DAS, poplar tree spacing S3 (5×3 m) with potato variety V2 (Kufri Neelkanth) produced significantly taller plants, i.e., 63.65 cm during 2021-22 and 63.96 cm during 2022-23. At 90 DAS, again poplar tree spacing S3 (5×3 m) with variety V2 (Kufri Neelkanth) produced significantly taller plants, i.e., 66.74 cm during 2021-22 and 65.26 cm during 2022-23. This might be due to the fact that during the time period different varieties of potato seemed to be acclimatized to the available space for growth and development. Optimum poplar tree spacing S3: 5×3 m provided better chances for having optimum solar radiation, water and essential nutrients along with competition for the same resources ([18-28]). Control plots where only sole crop of potato was grown, i.e., S5 with variety Kufri Bahar (V1) produced smaller potato plants at 30 (11.00 cm and 12.26 cm), 60 (20.66 cm and 21.57 cm) and 90 DAS (28.55 and 33.19 cm) during 2021-22 and 2022-23. This might be due to the fact that microclimate may not be available to control plots leading to loss of soil moisture, leading stunted growth.

Tuber yield

The poplar tree spacing S4: 6×3 m with variety V3: Kufri Lima resulted in significantly higher tuber yield during both the years, i.e., 418.19 and 421.20 q/ha during 2021-22 and 2022-23, respectively. However, sole cropping of potato (S5) with variety Kufri Lima (V3) resulted into higher tuber yield during both the years (425.30 and 427.30 q/ha), respectively. This indicates that varieties with higher vigor and yield potential respond more favorably to reduced competition. The results suggest that moderately wider spacings (6×3 m) can serve as an optimum compromise, ensuring reasonable tuber yield while maintaining tree growth and agroforestry sustainability.

Chlorophyll content

According to Tables 1, the chlorophyll content index (CCI) of potato leaves was significantly influenced by both spacing treatments and varietal differences at all growth stages (30, 60, and 90 DAS). Significantly higher chlorophyll content was recorded under closer spacings of poplar tree S1: 3×3 m with potato variety V3 (Kufri Lima) i.e., 26.92 cm at 30 DAS which was found at par with S2: 4×3 m with potato variety V3 (Kufri Lima) i.e., 26.60 cm during 2021-22. Same results have been obtained during 2022-23.

Poplar tree spacing S1: 3×3 m with potato variety V1: Kufri Bahar and V3: Kufri Lima resulted into significantly higher chlorophyll content with soil plant analysis development (SPAD) values (36.97 and 35.87) in potato leaves at 90 DAS during 2021-22. However, during 2022-23, poplar tree spacing S1: 3×3 m and S2: 4×3 m with potato variety V3: Kufri Lima resulted into significantly higher chlorophyll content with SPAD values (36.45 and 36.36) in potato leaves at 90 DAS but were found at par with each. Sole cropping (S5) with variety V2: Kufri Neelkanth of potato resulted in lower chlorophyll content in leaves at 90 DAS during 2021-22 and 2022-23, i.e., chlorophyll content with SPAD values14.15 and 15.89, respectively. Wider spacing supposed to provide more solar radiation and more green plants having higher content of chlorophyll [26] in guava. In contrast to this, the present study results revealed that closer spacing of potato resulted in higher chlorophyll content in the potato leaves sown in available space. This might be due to availability of microclimate leading to lesser evapotranspiration of moisture from space due to shading effect of poplar tree canopy. Other factors might be involved like competition for soil, moisture and nutrients in closure spacing insist potato plants to thrive best for survival. This suggests that the partial shade provided by poplar trees under narrower spacings may have enhanced chlorophyll synthesis by reducing photo-oxidative stress and promoting better leaf greenness during early crop establishment [27]. The trend indicates that optimal shade in closer spacings could have delayed senescence and improved pigment stability, which is consistent in chlorophyll content at this stage [28] due to chlorophyll degradation during the later stages of crop growth is a physiological response to resource reallocation towards reproductive/tuber development.

Table 1: Effect of poplar tree spacing on plant height, total tuber yield and chlorophyll content in potato during 2021-22 and 2022-23

Treatments	Plant height (cm)						Total tuber yield (q/ha)		Chlorophyll content (SPAD) of potato leaves					
	30 DAS		60 DAS		90 DAS				30 DAS		60 DAS		90 DAS	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
S1V1	17.00	17.59	31.33	31.46	44.28	43.40	212.8	215.9	25.21	25.34	40.20	40.44	36.97	34.99
S1V2	31.00	31.69	49.00	48.62	53.41	52.67	148.9	153.5	20.98	21.06	24.33	24.49	24.69	24.89
S1V3	20.22	21.03	35.33	35.83	45.55	47.03	256.6	259.5	26.92	27.04	43.33	43.40	35.87	36.45
S1V4	25.99	26.86	42.00	42.20	46.38	51.68	191.7	193.2	24.39	24.54	37.49	37.61	35.75	32.15
S1V5	28.66	29.40	45.00	44.94	48.44	49.37	187.8	191.4	21.16	21.66	28.76	28.89	28.90	29.12
S1V6	23.00	23.40	39.00	38.94	44.20	42.46	190.0	192.2	22.82	22.81	33.01	33.14	32.90	31.98
S2V1	16.99	17.59	26.33	26.77	36.58	36.46	309.3	311.2	24.06	24.16	36.32	36.43	33.18	35.12
S2V2	33.00	32.98	47.00	47.20	53.66	52.00	187.5	189.6	19.94	20.14	21.96	22.08	21.98	22.17
S2V3	20.00	20.56	31.65	31.89	35.67	42.07	328.7	329.4	26.60	26.72	41.30	41.90	34.56	36.36
S2V4	27.00	27.34	40.66	41.03	45.04	51.65	269.3	271.4	23.23	23.33	32.59	32.75	32.65	34.59
S2V5	30.00	30.12	44.00	44.08	46.78	48.38	223.9	225.2	21.51	21.27	24.34	24.54	24.74	24.89
S2V6	23.66	23.75	36.00	36.29	45.53	46.20	248.1	249.6	22.70	22.82	25.47	25.60	25.48	25.69
S3V1	21.00	21.94	34.00	34.17	43.11	42.27	312.5	314.9	23.19	23.32	30.70	30.80	27.38	27.60
S3V2	40.65	40.39	63.65	63.96	66.74	65.26	214.0	216.8	19.73	19.90	17.59	17.69	17.78	17.99
S3V3	24.00	23.51	39.66	40.11	42.47	50.41	339.2	341.3	24.44	24.61	33.58	33.70	31.45	31.08
S3V4	32.33	31.67	56.00	55.70	61.48	63.19	277.5	278.2	22.93	23.03	27.16	27.30	27.10	26.91
S3V5	36.00	36.30	60.00	59.78	64.33	63.67	240.7	243.6	20.96	21.11	20.68	20.86	20.43	20.89
S3V6	25.00	23.79	45.00	45.01	52.44	51.53	256.2	258.5	21.70	21.79	24.24	24.38	24.21	24.41
S4V1	24.00	25.03	32.33	32.57	41.89	43.32	318.0	350.3	22.58	22.71	29.09	29.22	25.22	23.55
S4V2	43.00	43.00	51.00	51.30	52.34	60.43	237.8	239.1	19.16	19.29	17.52	17.62	16.56	16.45
S4V3	28.66	29.92	36.00	35.90	40.01	44.81	418.9	421.2	23.76	23.87	31.50	31.10	25.45	27.56
S4V4	36.66	37.90	42.99	43.58	47.07	52.38	294.4	296.7	21.94	22.10	26.54	26.65	25.12	23.14
S4V5	39.99	39.88	46.66	47.14	47.93	55.42	285.6	286.5	20.29	20.41	20.72	20.86	18.59	19.45
S4V6	32.33	32.13	28.33	40.50	41.89	46.52	290.3	292.7	20.51	21.07	23.20	23.36	21.48	22.89
S5V1	11.00	12.26	20.66	21.57	28.55	33.19	342.6	345.2	19.56	19.48	26.45	25.98	22.12	20.12
S5V2	31.00	30.85	46.65	46.83	50.17	51.97	260.5	262.5	16.25	16.56	15.48	16.54	14.15	15.89
S5V3	13.99	14.30	24.99	25.57	37.06	35.22	425.3	427.3	19.78	19.52	27.65	28.50	24.56	25.64
S5V4	20.65	22.05	32.65	33.16	38.97	44.17	335.2	338.4	18.45	18.57	24.57	23.51	21.88	19.64
S5V5	24.66	24.19	38.65	38.91	44.13	46.73	305.2	309.3	17.14	17.62	18.15	17.99	14.64	17.99
S5V6	17.00	18.10	28.32	28.53	32.25	35.64	315.2	318.6	16.99	17.98	19.26	18.24	18.59	19.62
CD @ 5%	0.80	1.81	2.67	2.00	1.50	1.39	4.9	4.9	0.62	0.61	2.39	2.38	0.61	0.59

S1: 3×3 m, S2: 4×3 m, S3: 5×3 m, S4: 6×3 m, S5: Sole Crop
V1: Kufri Bahar, V2: Kufri Neelkanth, V3: Kufri Lima, V4: Kufri Ganga V5: Kufri Pushkar, V6: Kufri Pukhraj

Conclusion

Based on the above study, it can be concluded that Kufri Lima was found most suitable variety for potato cultivation under poplar-based agroforestry system with wider spacing of 6×3 m.

Acknowledgements

The Department of Forestry is duly acknowledged for providing different resources to carry out the present study. CCS Haryana Agricultural University is also acknowledged to provide the opportunity to carry out the Ph.D. Research for providing financial assistance.

References

1. Nair PKR. An introduction to agroforestry. Springer; 1993. 499 p.
2. Department of Agriculture and Cooperation. National Agro-forestry Policy 2014. Ministry of Agriculture, Government of India; 2014.
3. Kaushik N, Tikkoo A, Yadav PK, Deswal RPS, Singh S. Agri-silvi-horti systems for semi-arid regions of North-West India. Agric Res. 2017;6(2):150-158.
4. Henareh J, Ahmadloo F, Pato M. Evaluation of yield and financial advantage of intercropping of poplar (*Populus nigra* 62/154) with alfalfa (*Medicago sativa* L.) at Saatlou poplar research station of Urmia. For Res Dev. 2025;10(4):453-477.
5. Sarvade S, Mishra HS, Kaushal R, Chaturvedi S, Tewari S. Wheat (*Triticum aestivum* L.) yield and soil properties as influenced by agri-silviculture systems of terai region, northern India. Int J Bioresour Stress Manag. 2014;5(3):350-355.
6. Kulkarni HD. Industrial agroforestry: An Indian Tobacco Company initiative. Indian J Agrofor. 2013;15:49-54.
7. Pandey DN. Multifunctional agroforestry systems in India. Curr Sci. 2007;92:455-463.
8. Dhillon RS, Johar V, Beniwal RS, Bhardwaj KK, Kumari S, Chavan SB, Sirohi C. Effect of spacing geometries of *Populus deltoides* on carbon sequestration potential of poplar-based agroforestry system in Haryana. J Pharm Phytochem. 2018;7(3):2968-2971.
9. Bangarwa KS, Wuehlich GV. Using exotic poplar in northern India for higher returns in agroforestry. Asia Pac Agrofor News. 2009;35:3-5.
10. Jain SK, Singh P. Economic analysis of industrial agroforestry: poplar (*Populus deltoides*) in Uttar Pradesh, India. Agrofor Syst. 2000;49:255-273.
11. Chauhan SK, Sharma R, Singh B, Sharma SC. Biomass production, carbon sequestration and economics of on-farm poplar plantations in Punjab, India. J Appl Nat Sci. 2015;7(1):452-458.
12. Solomon-Blackburn RM, Barker H. Breeding virus-resistant potatoes (*Solanum tuberosum*): traditional and molecular approaches. Heredity. 2001;86(1):17-35.
13. Pandey SK, Sarkar D. Potato in India: emerging trends and challenges. Potato J. 2005;32:93-104.
14. Singh J, Singh A, Chauhan SK. Impact of manipulating poplar canopy on microenvironment and marigold yield under agri-silviculture system. Indian J Agrofor. 2019;21(2):48-52.
15. Bhandari N, Gill RIS, Singh B, Dhatt AS. Effect of varieties and sowing time on potato under poplar-based agroforestry system. Indian J Agrofor. 2015;17(1):29-35.
16. Korwar GR, Pratibha G, Ravi V, Palani KD. Performance of castor and green gram in agroforestry systems in semi-arid tropics. Indian J Agron. 2006;51(2):112-115.
17. Mac Dickens KG, Vergara NT. Agroforestry classification and management. John Wiley & Sons; 1990.
18. Horn HS. The adaptive geometry of trees. Princeton University Press; 1971.
19. King DA. The adaptive significance of tree height. Am Nat. 1990;135(6):809-828.
20. Trees RF. Asymptotic height as a predictor of growth and allometric characteristics in Malaysian trees. Am J Bot. 1996;83(5):556-566.
21. King DA, Davies SJ, Supardi MN, Tan S. Tree growth related to light interception and wood density in Malaysian mixed dipterocarp forests. Funct Ecol. 2005;19(3):445-453.
22. King DA, Davies SJ, Noor NSM. Growth and mortality related to tree size in a Malaysian mixed dipterocarp forest. For Ecol Manag. 2006;223(1-3):152-158.
23. King DA, Wright SJ, Connell JH. Contribution of variation in maximum tree height to tropical and temperate diversity. J Trop Ecol. 2006;22(1):11-24.
24. Xiao S, Chen SY, Zhao LQ, Wang G. Density effects on plant height growth and inequality in sunflower populations. J Integr Plant Biol. 2006;48(5):513-519.
25. Givnish TJ. Adaptive significance of leaf height in forest herbs. Am Nat. 1982;120(3):353-381.
26. Tripathi A, Sehrawat SK, Dahiya DS. Effect of spacing and pruning on chlorophyll and NPK contents of guava cv. Hisar Safeda. Int J Chem Stud. 2020;8(2):1039-1041.
27. Singh V, Singh B, Singh R. Growth and yield of potato under poplar-based agroforestry system. Agrofor Syst. 2018;92(5):1283-1292.
28. Taiz L, Zeiger E. Plant physiology and development. Sinauer Associates; 2015.
29. Bhandari N, Gill RIS, Singh B, Dhatt AS. Effect of varieties and sowing time on potato under poplar-based agroforestry system. Indian J Agrofor. 2015;17(1):29-35.