Int J Adv Life Sci Res. Volume 9(1) 96-105
https://doi.org/10.31632/ijalsr.2026.v09i01.007

International Journal of Advancement in Life Sciences Research

Online ISSN: 2581-4877

Journal homepage http://ijalsr.org

Original Article

Assessment of Disease Severity of Mulberry (*Morus alba* L.) var.S1 Concerning Soil Physiochemical Properties Under Three Districts of West Bengal India

Siraj Monir[1*], Pijush Mallick[2], and Mohan Kumar Biswas[1]

[1]Department of Plant Pathology, Palli Siksha Bhavana, Sriniketan, University of Visva-Bharati, Santiniketan, West Bengal 731 236, India

[2]Department of Agriculture Sciences, Techno India University, Saltlake, Kolkata 700 091, India

**Corresponding Author's Email: sirajmonir007@gmail.com*

Abstract

A study was conducted on the effect of soil health and its consequences on disease severity in popular S1 mulberry variety (*Morus alba* L.) under three districts Birbhum, Malda, and Murshidabad, West Bengal where sericulture is being practiced since last few decades. The physiochemical properties, like soil pH, EC, OC, and NPK content were measured under the said districts. The soil pH of mulberry fields in Birbhum (72%) were found <6.5, in Malda (84%) within 6.5-7.5, and in Murshidabad (68%) within 6.5-7.5. The soil electrical conductivity (EC) was found to be 0.5 under 88% area in Malda and Murshidabad and 84% area in Birbhum districts, respectively. The soil organic carbon (OC) was found 5 g/kg in Murshidabad and Birbhum districts under 84% and 82% area, respectively. The soil nitrogen was recorded 44 - 445 kg/Ha in Murshidabad under 60% area, whereas in Malda, it varied between 32-493 kg/Ha under 64% area. The soil phosphorus was recorded 2-204 kg/Ha in Murshidabad under 16% area, whereas in Malda, it varied between 11-81 kg/Ha under 24% area. The soil potassium was recorded 52-985 kg/Ha in Murshidabad under 14% area, whereas in Malda, it varied between 105-832 kg/Ha under 13% area. The soil NPK of Birbhum district was found to be very poor. The highest PDI was recorded in Birbhum of bacterial leaf spot (avg. 11.82%), in Malda, *Myrothecium* leaf spot (avg. 5.56%) and in Murshidabad, bacterial leaf spot (avg. 8.94%) among all the five diseases studied. Comparatively mulberry leaf rust disease shown less sensitivity with all soil edaphic factors.

Keywords: *Disease Severity; Mulberry; Percent Disease Index; Soil Edaphic Factors*

Introduction

Mulberry is a fast-growing deciduous and perennial plant, mainly cultivated for leaf production for commercial silkworm rearing under various soil conditions across the world. Therefore, soil sampling plays a crucial role in optimum leaf production. Soil analysis at various geographical locations has already been carried out on this crop and found significant results on variety-wise leaf production. Studies on soil fertility increments concerned to nutrient availability for optimum mulberry leaf yield via manuring and irrigation have been done (Jaishankar & Dandin, 2005; Prasanna *et al*., 2025). The physiochemical properties of soil play a significant role in quality mulberry leaf production and disease prevalence (Hillel, 1980; Zhang *et al*., 2018, 2021; Fan *et al*., 2024; Jiang *et al*., 2025). Soil organic carbon, nutrients, and other physiochemical properties are important parameters in controlling the sustainability of mulberry crop production (Nagaveni *et al.,* 2003; Lal, 2004 & Zhu *et al*., 2025). There

Received on :3rd April 2025; Revised version received on :17th December 2025; Accepted: 23rd December 2025

is a close relationship between fertilizer doses and quality mulberry leaf production in different ratios of organic and chemical fertilizers applied for the enrichment of NPK. However, it was observed through systematic assessment of soil fertility status where mulberry grew inefficiently in some parts of West Bengal (Samanta *et al.,* 2002). The study highlighted the factors like nutrient depletion followed by adding chemical fertilizers, which showed adverse effect on mulberry foliar production (Banuprakash *et al.,* 2024). Thus the interest grew to study on the cultivated soil condition particularly chemical properties and its essential nutrient status including organic carbon; NKP, and other micro elements based on the tested recommendation (Kar *et al*., 2018; Sudhakar *et al*., 2018).

The physical properties of soil affect its quality and productivity of nutrient elements (Hillel, 1980). Most of the scientist reported that the pH of soil is play a vital role of physiochemical characteristic that determines not only the suitability of soil for crop productivity but also affects soil physical character like structure, texture and permeability including rhizospheric microbial diversity ultimately effect on plant growth. It is reported that the soil organic carbon plays an important role controlling sustainable crop production without any significant failure (Lal, 2004). Additionally, it has found that the organic carbon in agricultural land increases soil fertility and productivity in many crops (Nagaveni *et al.,* 2003). The organic carbon significantly promotes the attributes of desirable traits like structure which influences the optimum aeration and retention capacity of moisture content (Subbiah & Asija, 1956).

In West Bengal, the Birbhum, Murshidabad, and Malda districts have been famous for the sericulture industry for a long time (Bose et al., 2010). Apart from mulberry cultivation, farmers of the said districts are engaged in other agricultural activities and crop production on the same fields. As a result, mulberry plants frequently remove their assimilatory appendages (about five times a year) for the systematic evaluation of soil fertility in these districts (Samanta *et al*., 2002). In this situation, the soil nutrient status may decrease, which results poor leaf production unless fertilizers are applied sufficiently and lack of technology adaptation tendency at farmers level (Sengupta *et al.,* 2024). However, in this study authors have shown the effectiveness of soil physiochemical properties on disease severity of mulberry under the said three districts of West Bengal.

Material and Methods

Locale of the Study

The experiment was conducted for the development of an integrated package of practice for two years, from 2013 - 2014, in Birbhum, Malda, and the Murshidabad district of West Bengal, under irrigated lateritic and gangetic alluvium soil conditions.

Survey and Sampling

A total of 75 Soil samples from the 25 farmers of each district, viz., Malda, Murshidabad, and Birbhum of West Bengal, were collected. Soil sampling was done by collecting 30 cm depth soil from each district just after pruning of mulberry plants during the month of February.

Soil Testing

Each 200 gm soil samples from the said three districts were collected, then air dried under the shade, and powdered. Then the samples were sieved through a 2 mm porous sieve, and collected the fine powder. A portion of each samples were again sieved through a +0.4 mm sieve for the estimation of organic carbon. The pH and EC of the soil samples were determined using the protocol of Black (1986), followed by organic carbon estimation by Walkley and Black (1934). Available nitrogen (kg ha-1) was estimated by the alkaline potassium permanganate according to the protocol given by Subbaiah and Asija (1956). Available phosphorus (kg ha-1) was estimated by the method proposed by Olsen *et al* (1954), and available potassium was estimated by the method given by Jackson (1973).

Assessment of Disease Severity

To determine a relationship between various disease severity levels of mulberry var. S1 and soil edaphic factors, data were collected under the three districts. All data were recorded from the mulberry

field where the important soil edaphic factors like pH, electrical conductivity, organic carbon, nitrogen, phosphorus, and potassium were under this study. The data about a total of five different mulberry diseases and their severity were tabulated and analysed using Percent Disease Index (PDI) and established their relationships with soil edaphic factors.

Results

Status of soil pH

The pH level of Birbhum district was observed to be slightly acidic compared to Malda and Murshidabad districts. In Birbhum district, about 72% fields were found pH of <6.5, about 20% within the range of 6.5-7.5, and 8% >7.5. In Malda district, a pH range of 6.5-7.5 was found in a maximum of 84% area and >7.5 of 12% area, and >6.5 pH in 4% area. Whereas, in the Murshidabad district, 68% area was under a pH of 6.5-7.5, about 24% area was>7.5, and 8% area was in the range of >6.5 pH (Fig.1).

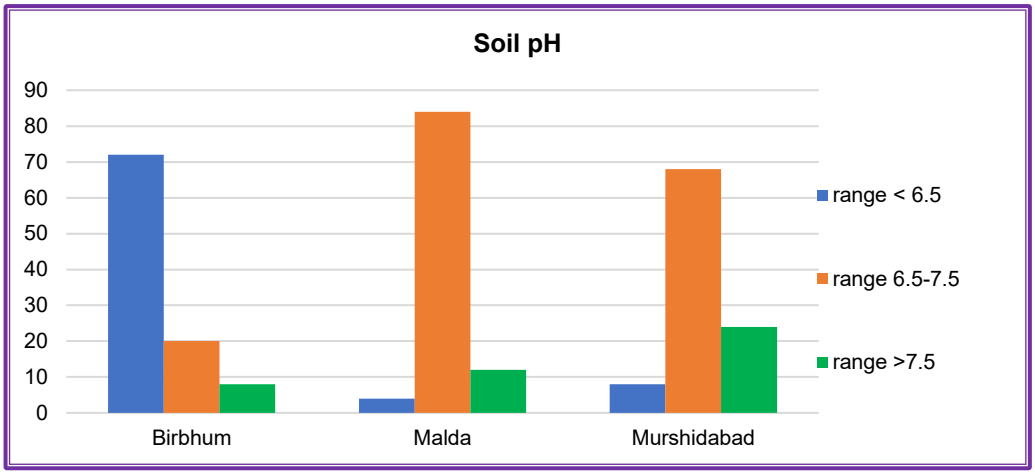

Figure 1: *Soil Ph Under Mulberry Cultivated Area of the Three Districts of West Bengal.*

Status of Soil Electrical Conductivity (dSm-1)

The soil EC (electrical conductivity) of Malda, Murshidabad, and Birbhum districts was found in the range of <0.5, under 88% area of Malda and Murshidabad, and 84% area in Birbhum districts. A few percentages of soil samples showed an electrical conductivity range of 0.5-1.0. However, none of the soil samples exhibited electrical conductivity >1.0 (Fig.2).

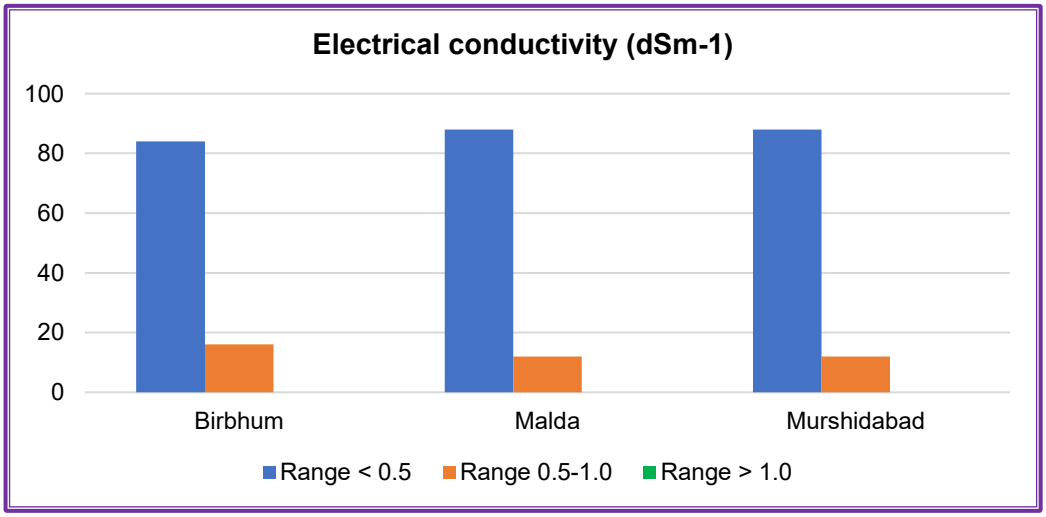

Figure 2: *Electrical Conductivity (Dsm-1) of Soils Under Mulberry Cultivated Area of The Three Districts of West Bengal*

Status of Soil Organic Carbon

The percentages of soil organic carbon were recorded and found in the scale of <1 to >10 under the three said districts (Fig.3). Most of the soil samples of Murshidabad and Birbhum districts showed the organic carbon content of < 5 (g kg-^{1}) in 84% and 82% area, respectively. However, data showed a higher range of organic carbon 5-10 (g kg-^{1}) in the soils of Malda district in 68% area.

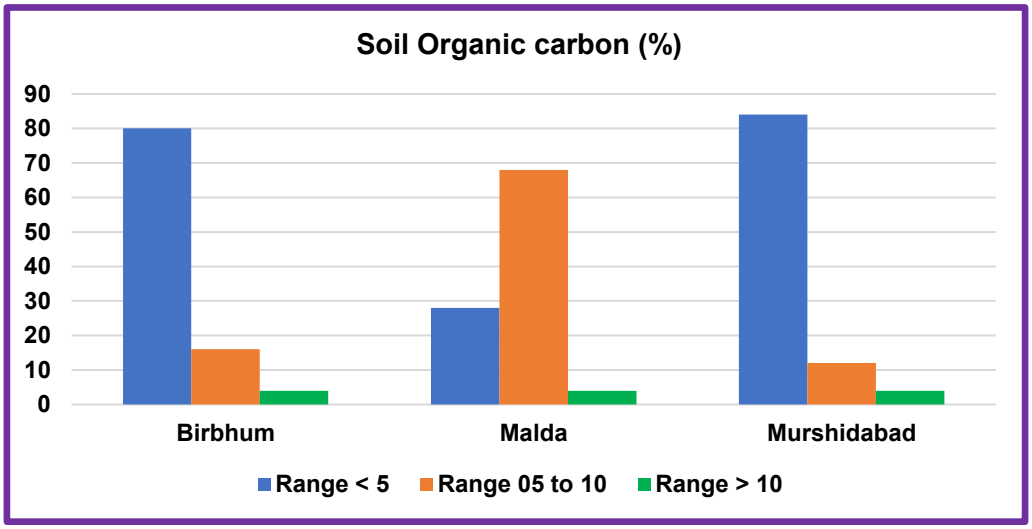

Figure 3: *Soil Organic Carbon Content Under Mulberry Cultivated Area of the Three Districts of West Bengal*

Available soil NPK status under the three districts

The soil nitrogen level depicted a huge variation under the three districts (Fig.4). It was found at 44 - 445 (kg Ha-^{1}) under 60% area of Murshidabad district. In Malda district, it was found in a range of 32-493 (kg Ha-^{1}) under 64% area. In Birbhum district, it was found to be a very poor amount under 72% area.

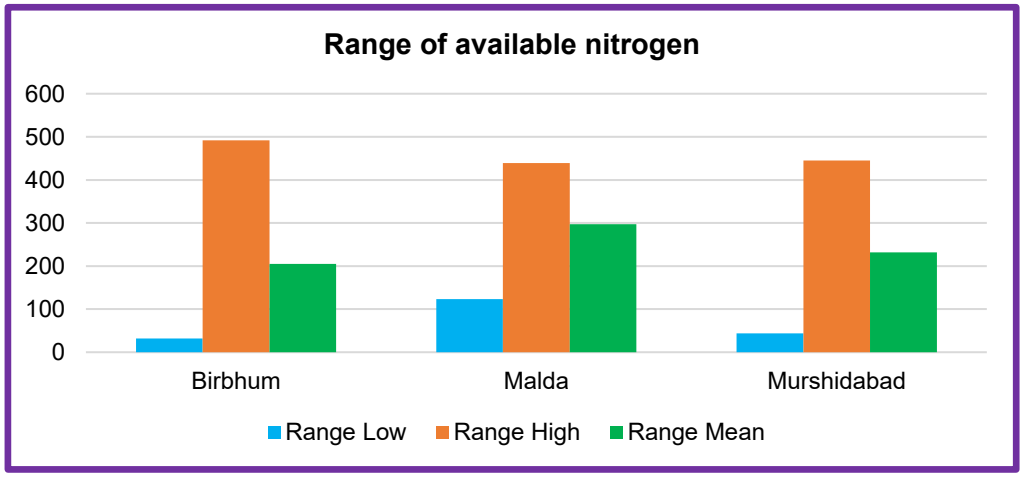

Figure 4: *Available Nitrogen (Kg Ha-^{1}) Content of Soils Under Mulberry Cultivated Area of the Three Districts of West Bengal*

The soil phosphorus level depicted a huge variation under the three districts (Fig.5). The phosphorus content was recorded in Murshidabad district of 2-204 (kg Ha-^{1}) under 16% area. In Malda district, it was found of 11-81 (kg Ha-^{1}) under 24% area, whereas in Birbhum district, it was found to be a very poor amount under 24% area.

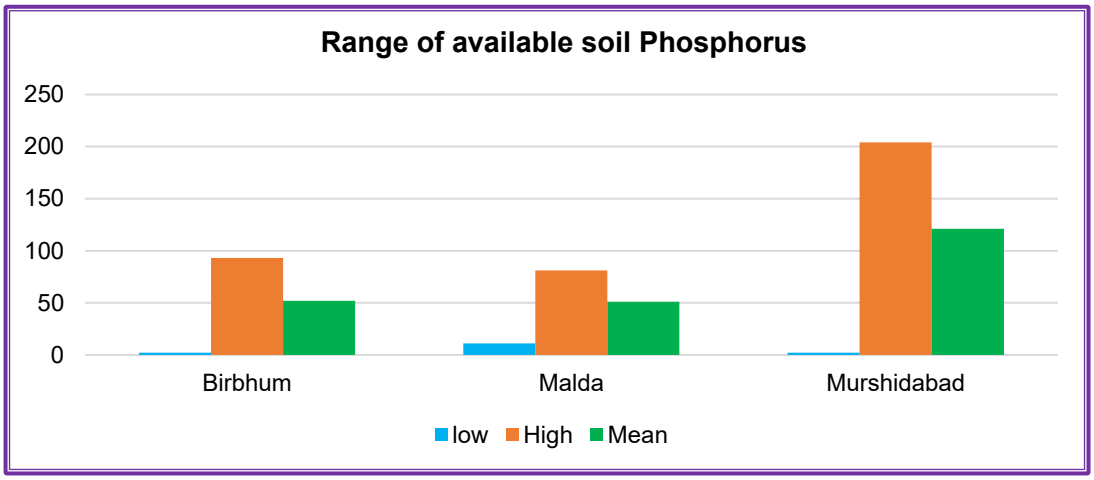

Figure 5: *Available Phosphorus (Kg Ha-[1]) Content of Soils Under Mulberry Cultivated Area of the Three Districts of West Bengal*

The soil potassium level depicted a huge variation under the three districts (Fig.6). The potassium content was recorded in Murshidabad district of 52-985 (kg Ha-[1]) under 14% area. In Malda district, it was found of 105-832 (kg Ha-[1]) under 13% area; in Birbhum district, it was found to be very poor amount under 14% area.

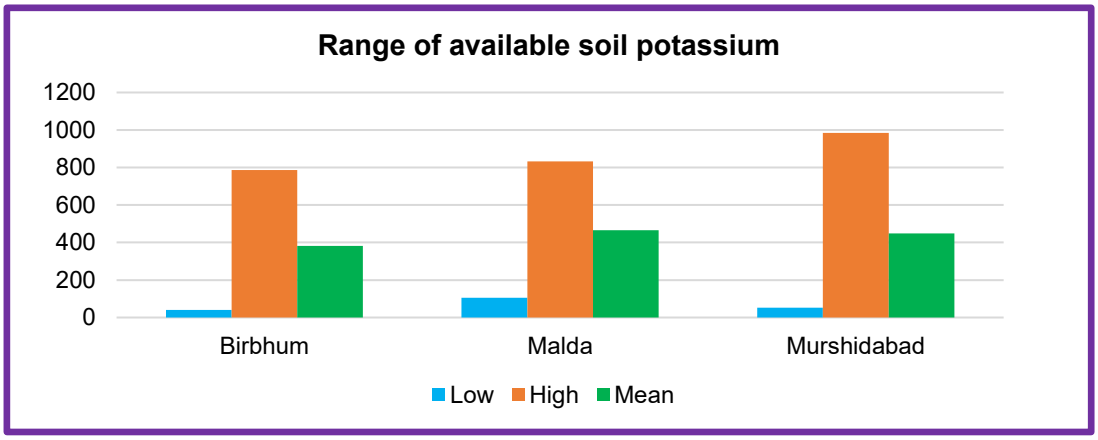

Figure 6: *Available Potassium (Kg Ha-[1]) Content of Soils Under Mulberry Cultivated Area of the Three Districts of West Bengal*

Level of mulberry disease severity concerning the soil edaphic factors

In this study, a total of five mulberry diseases, *i.e.*, *Myrothecium* leaf spot, Bacterial leaf spot, *Pseudocercospora* leaf spot, powdery mildew, and leaf rust, were considered as per their highest prevalence (PDI, Percent Disease Index) in West Bengal (Table1). Among the diseases, powdery mildew and leaf rust were not common in Birbhum district. Bacterial leaf spot was a very prominent disease in Birbhum district, and a range of 7.25% - 12.35% and an average of 11.82% PDI was observed, followed by an average of 8.94% and 2.88% PDI in Murshidabad and Malda districts, respectively. *Myrothecium* leaf spot was quite common in the three districts, and an average PDI of 5.56%, 4.70%, and 4.60% were recorded in Malda, Murshidabad, and Birbhum districts, respectively. The severity level of *Pseudocercospora* leaf spot was found in the range of 6.25% - 13.24% with an average of 7.20% PDI in Murshidabad district and a minimum of 1.02% - 3.24% with an average of 2.30% in Malda district. The range of powdery mildew and leaf rust were found to be 1.14% - 6.25% and 1.00% - 3.24% PDI, respectively, in Murshidabad, and 1.00% - 4.26%, and 1.24% - 5.10% PDI, respectively, in Malda district (Fig.7).

Table 1: *Disease Severity Level of Different Mulberry Diseases of West Bengal*

District	Myrothecium leaf spot (% PDI)		Pseudocercospora leaf spot (% PDI)		Bacterial leaf spot (% PDI)		Powdery mildew (% PDI)		Leaf Rust (% PDI)	
	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.
Birbhum	1.25 - 9.35	4.60	4.15- 9.25	6.97	7.25 - 12.35	11.82	0.00	0.00	0.00	0.00
Malda	3.15 - 1.25	5.56	1.02 - 10.34	2.30	1.02 - 3.24	2.88	1.0 - 4.26	2.81	1.14 - 5.11	3.52
Murshidabad	3.48 - 6.44	4.70	5.14 - 9.35	7.20	6.25 - 13.24	8.94	1.14 -6.25	3.14	1.0 - 3.24	1.99

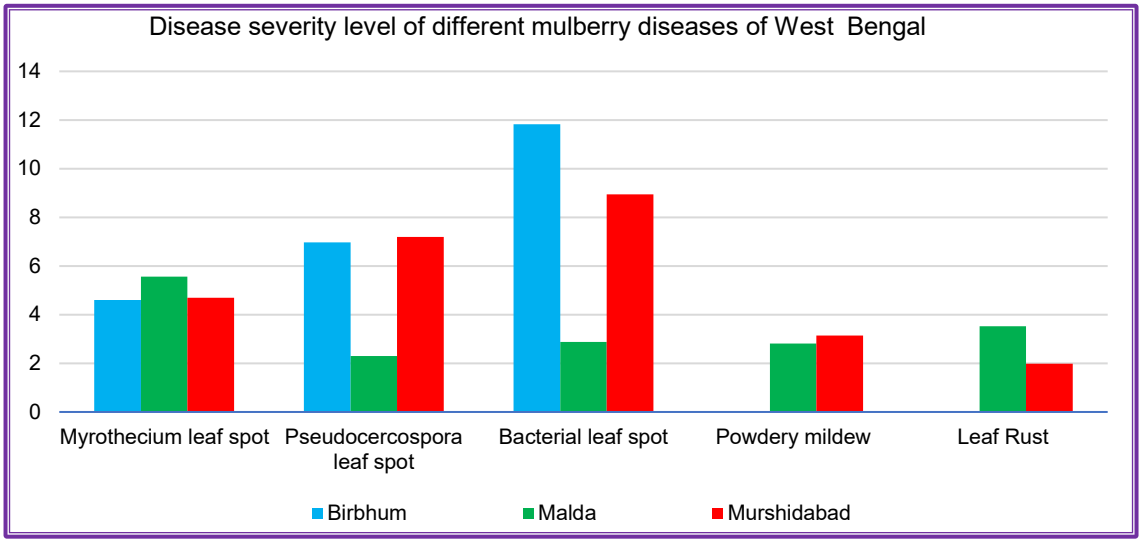

Figure 7: *Disease Severity Level of Different Mulberry Concerning Edaphic Factors Under the Three Districts of West Bengal*

Discussion

Present findings regarding the pH of soil indicated a wide range in general, *i.e.,* highest under 84% area in Malda district ranging 6.5-7.5, in Murshidabad district 68%, and Birbhum district 72% area at >6.5 in the soil depth irrespective of seasons and the fertilizer levels thereof. In the past, Vrajan *et al.*(2021), showed that the soils of Malda district under 79%, Murshidabad district under 59% and Birbhum district under 31% area had a suitable pH range i.e., 6.5-7.5 for optimum mulberry growth. An increase in soil pH could be attributed to the leaching of bases and variation in the organic matter, as reported by Vrajan *et al.* (2021). The present findings also corroborate with the findings of Kar *et al.* (2018) and Sudhakar *et al.* (2018). The findings are having similarities with the reports published by Kar *et al.* (2011) and Naidu *et al.* (2019). The findings indicate a severe deterioration of soil chemical nature in the mention districts.

Electrical conductivity was highest in the soil of Malda and Murshidabad. Pooled data showed that the soils at Malda and Murshidabad recorded electrical conductivity of 88 (0.5). The variation in electric conductivity under three different Agro-climatic zones could be attributed to the leaching of soluble salts from surface to subsurface horizons. In agreement with previous findings by Ram and Maji, 2018; Kar *et al*., 2009, the EC values under the studied districts were found to be normal (EC ≤ 2). Such normal EC in the mentioned soils might be occurred for the leaching of salts below the rhizospheric zone due to high rainfall (Prasenjit *et al*., 2018; Kar *et al*., 2011). The water quality under the ground level used here for irrigation purposes on such fields could also be one of the important factors for the higher salinity status (Christine *et al*., 2018). Prasenjit *et al* (2018) and Kar *et al.* (2011), also studied and found the similar soil nature for mulberry cultivation in West Bengal.

The presence with the highest organic carbon content was in Murshidabad 84% (g kg^{-1}) then Birbhum 80% (g kg^{-1}) for a range of below 5 per cent, but Malda 68% under 5 to 10% range. The organic carbon

ranges of < 0.5 in soil of Malda and Murshidabad area could be attributed to the mixing of crop residues and fallen leaves into the soil system after the harvest as a good number of fruits like mango, litchi and other crops like jute, rice is cultivated in Malda and Murshidabad. Differences between zones were found to be significant. The phenomenon of organic carbon range <0.5 trend along the soil depth could be due to the incorporation of crop residues and fallen leaves into the soil system, as also reported by Tang *et.al.,* (2024). Further, the leftover crop residues and fallen leaves might have also resulted in increased interaction with the soil microbial complex, thereby changing the C:N ratio. The phenomena of higher organic carbon found under the said districts that might be occurred due to the possible accumulation of soil organic matter in the rhizospheric region. Nevertheless, lower to medium status of organic carbon under the study area could be attributed to a deficit application of recommended doses of organic manure like cow dung. Such phenomena indicate some repair mechanism to be applied to rejuvenate soil health under the said districts due to significant role of soil OC content for deep-rooted plants like mulberry.

The available soil nitrogen plays an important role in the nutrition enrichment of mulberry plants. The nitrogen, being a constituent of protein, has an important part of the cellular protoplasm, enzymes and chlorophyll synthesis in plant kingdom. Shankar (1997) had published a report on the quality leaf production in mulberry depends on the availability of leaf nitrogen. Again, soil nitrogen showed a huge deviation in values as recorded under the three districts in this study. The highest soil nitrogen content was recorded at Murshidabad 44-445 (kg Ha-^{1}), with 60% low range and 40% medium. In Malda site with the average value of 132-493 (kg Ha-^{1}) in 64% medium and 36% low range, and in Birbhum 34-492 (kg Ha-^{1}), with a range of 72% low and 28% medium but no high range percent in the three districts. The values between the three districts showed significant differences. A significant finding on the lower availability of nitrogen content under mulberry-growing soils might have large-scale implications on the nitrogen and moisture content of leaves (Ray *et al.,* 2021). The positive effect of application of nitrogen in mulberry cultivated land induce leaf productivity and quality with enhanced silkworm cocoon characters having commercial values (Ahmed *et al.*, 2022).

Phosphorus plays a role in early root development and the overall growth of any plants. This element is constituent of many organic compounds in plants like; nucleic acids, phosphorites, co-enzymes, NAD, NAPD and ATP. However, it is in close relationship with the synthesis of plant proteins, metabolism of fats, carbohydrates, photosynthesis and other metabolic activities. It contributes to leaf maturity. Available soil phosphorus was recorded maximum soil phosphorus during both the years of study the highest range of available soil phosphorus at Murshidabad 2-204 (kg Ha-^{1}) with high % of different classes of nutrient, Malda 11-81 (kg Ha-^{1}) of low, medium and high such as 4, 10 and 14% of different classes of nutrient, similarly Birbhum range of 2-93 (kg Ha-^{1}) with low 24, medium 14 and high 5% of different classes of nutrient. In a condition like, precipitation of phosphorus as iron and aluminium complexes due to the acidic reaction of soil might be one of the important factors for lower concentration of phosphorus level in these soils (Prasenjit *et al.,* 2018).

Like others, potassium also plays an important role in photosynthetic water regulation by maintaining the turgidity of cells, inducing resistance against pests and diseases, cold breeze injuries and other adverse abiotic stress conditions by the plant kingdom. This element is involved in many enzymatic pathways in plant system. Report by Minamizawa (1997), it was observed that under the potassium-deficient soil conditions, photosynthesis rate is hampered and drastically reduced, when respiration rate became higher in plants. Soil potassium depicted a great variation in values as recorded in three districts. The highest soil potassium content was recorded at the Murshidabad site with an average value of 52-985 (kg Ha-^{1}), in Malda 105-832 (kg Ha-^{1}) and Birbhum 41-787 (kg Ha-^{1}). The values between the three zones showed significant differences. In this study, the status of available potassium under the said districts rated as lower due to the leaching of a good amount of soil potassium (~1.5 times of applied fertilizer) during the intensive cropping and harvesting system (Gurav *et al*., 2018). Both the elements, phosphorus and potassium aid in the efficient utilization of soil nitrogen, which ultimately influences the quality leaf production by mulberry (Shinde *et.al*., 2012).

Conclusion

Based on this study, it has been concluded that soil edaphic factors directly affect mulberry leaf production and overall plant growth. So, if proper care is taken before the mulberry plantation, like soil amendment, remediation of associate physiochemical properties, and making the soil perfect for optimum foliage production by reducing the disease severity thereof. Further study on rural awareness program may be conducted to promote adoption behaviour at farmers' level about the recommended package & practices in future.

Conflict of Interest

The authors declared that they do not have any conflict of interest.

Acknowledgement

The authors are thankful to Dr. S.K. Dutta, Scientist-D, CSR&TI, Berhampore, for his kind help and support in carrying out all experiments. The second author sincerely gives thanks to the honourable Chancellor and Vice-Chancellor of Srinath University, Jamshedpur, for their encouragement and all support.

References

Ahmed, F., Hossain, M. S., Uddin, M. A., & Ahmed, O. (2022). Prominent Doses of Nitrogen Enhance Mulberry and Silk Cocoon Productivity. *European Journal of Agriculture and Food Sciences*, *4*(1), 10-19. https://doi.org/10.24018/ejfood.2022.4.1.415

Banuprakash, K. G., Reddy, R. N., Pooja, L., Murthy, R. K., Raut, M., Thorat, A. K., ... & Rohitha, D. S. (2024). 2 Influence of Nanofertilizers on Growth and Yield of Mulberry and its Impact on Performance of the Silkworm, *Bombyx mori* L: An Overview. *Mysore Journal of Agricultural Sciences, 58*(2), 15-33. https://old.uasbangalore.edu.in/images/2024-2nd-Issue/2.pdf

Black, C. A. (1986). Methods of soil analysis, Part I. Physical and mineralogical properties, including statistics of measurement and sampling. Part II. Chemical and microbiological properties. *Agronomy series, ASA, Madison. Wis. USA*. https://www.scirp.org/reference/referencespapers?referenceid=1651287

Bose, P. C., Kar, R., & Bajpai, A. K. (2010). Soil test based sulphur fertilization for targeted yields of mulberry. *Journal of Crop and Weed*, *6*(1), 22-24. https://cwss.in/Journal/Complete_jurnal/Vol6_1__5.pdf

Christine, A. A., Kibet, J. K., Kiprop, A. K., & Were, M. L. (2018). The assessment of bore-hole water quality of Kakamega County, Kenya. *Applied Water Science*, *8*(1), 47. https://doi.ovrg/10.1007/s13201-018-0688-8

Fan, W., Kong, Q., Chen, Y., Lu, F., Wang, S., & Zhao, A. (2024). Safe utilization and remediation potential of the mulberry-silkworm system in heavy metal-contaminated lands: A review. *Science of the Total Environment*, *927*, 172352. https://doi.org/10.1016/j.scitotenv.2024.172352

Gurav, P. P., Ray, S. K., Choudhari, P. L., Biswas, A. K., & Shirale, A. O. (2018). A review on soil potassium scenario in vertisols of India. *Open Access Journal of Science*, *2*(1), 89-90. https://doi.org/10.15406/oajs.2018.02.00051

Hillel, D. (1980). *Fundamentals of soil physics*. Academic press. New York,.

Jackson, M. L. (1973). Soil chemical analysis, pentice hall of India Pvt. *Ltd., New Delhi, India*, *498*, 151-154.

Jaishankar, J., & Dandin, S. B. (2005). Studies on soil fertility status in relation to pattern of application of farmyard manure and chemical fertilizers in irrigated mulberry gardens of Kolar District, Karnataka. *Indian Journal of Sericulture,44*(1), 40-44. https://www.cabidigitallibrary.org/doi/full/10.5555/20063135522

Jiang, Y., Yang, X., Jiang, S., Tientega, A., Cao, H., Li, Z., ... & Long, T. (2025). Nitrogenous fertilizers affect Cd accumulation in the soil-mulberry-silkworm system: implications for safe utilization of contaminated farmland. *Environmental Monitoring and Assessment*, *197*(10), 1108. https://doi.org/10.1007/s10661-025-14588-0

Kar R., Vrajan, V., Ghosh M. K., Dutta, S. K., & Trivedy, K. (2018). Prediction of nitrogen availability based on soil organic carbon in commercial mulberry vegetation of Eastern India. *Journal of Soil Science Environment Management, 9*(3), 30-34. https://doi.org/10.5897/JSSEM2017.0650

Kar, R., Bose, P. C., Majunder, S. K., Dutta, R. N., & Bajpai, A. K. (2011). Characterization of soil acidity under the mulberry (*Morus* sp.) vegetation of Eastern India. *Journal of Interacademicia, 15*(1), 38-43. https://www.cabidigitallibrary.org/doi/full/10.5555/20113172311

Lal, R. (2004). Soil carbon sequestration impacts on global climate change and food security. *Science*, *304*(5677), 1623-1627. https://doi.org/10.1126/science.1097396

Minamizawa, K. (1997). *Moriculture: Science of mulberry cultivation*, 2nd edition, xi + 431 pp. A.A. Balkema, Rotterdam, Netherlands.

Nagaveni, V., Shree, M. P., & Shivashankara, B. R. (2001). Comparative study of soil fertility status in mulberry gardens of Mandya, Tumkur and Kolar districts of Karnataka. *Nutritional Management and Quality Improvement in Sericulture. Proc. Natl. Sem. Mulb. Seri. Res. India*, 175-178.

Naidu, B. V., Sobhana, V., Sudhakar, P., Sen, S., Obulapathi, N., Sneha, M. V., & Tiwari, P. (2019). Soil nutrient status of mulberry gardens in varied clusters of Andhra Pradesh. *Emergent Life Sciences Research*, *5*, 43-51. https://doi.org/10.31783/elsr.2019.524351

Olsen, S. R., Cole, C. V., Watanabe, F. S., & Dean, L. A. (1954). *Estimation of available phosphorus in soils by extraction with sodium bicarbonate*. USDA Circular No. 939, 1-19. https://www.scirp.org/reference/referencespapers?referenceid=1117235

Prasanna, C. L., Naveen, D. V., Veeranagappa, P., Naika, R., Srinivasan, R., & Venkatachalapathi, V. (2025). Mulberry leaf quality influenced by surface, subsurface manuring and fertilizer application in irrigated conditions of Karnataka. *International Journal of Advanced Biochemistry Research,* *9*(8), 262-267. https://www.doi.org/10.33545/26174693.2025.v9.i8Se.5144

Prasenjit, R., Gogoi, S. N., Bandyopadhyay, S., Padua, S., Jena, R. K., Roy, P. D., Ramachandran, S., Sharma, G. K., Sah, K. D., Trivedy, K., Singh, S. K., & Ray, S. K. (2018). Fertility status of mulberry (*Morus indica* L.) growing soils of upper Brahmaputra valley region of North Eastern India. Range Management & Agroforestry, 39(2), 147-155. https://publications.rmsi.in/index.php/rma/article/view/116

Ram, R. L., & Maji, C. (2018). A Comprehensive Review on Mulberry Sericulture in Kalimpong Hills. *International Journal of Current Microbiology and Applied Sciences*, *7*(8), 4850-4860. https://doi.org/10.20546/ijcmas.2018.708.511

Ray, P., Gogoi, S. N., Bandyopadhyay, S., Jena, R. K., Ramachandran, S., Sharma, G. K., ... & Ray, S. K. (2021). Soil-cum-nutrient management package for achieving high yield and quality of mulberry (*Morus indica* L.) leaf in acid soil of North Eastern India. *Journal of Plant Nutrition*, *44*(17), 2501-2513. https://doi.org/10.1080/01904167.2021.1921196

Samanta, A.B., Chatterjee, A., Mete, P.K., & Mandal, B. (2002). Status of Total and Available Iron and Zinc in Soils of West Bengal under Continuous Cultivation of Mulberry. *Journal of the Indian Society of Soil Science, 50*, 35-42. https://www.semanticscholar.org/paper/Status-of-Total-and-Available-Iron-and-Zinc-in-of-Samanta-Chatterjee/3608955e97881fdfcb970e3894206d357852105d

Sengupta, M., Biswas, S., & Saha, S. (2024). Assessment of Socio-Personal and Management Factors Affecting Farmer's Income from Sericulture in West Bengal, India. *International Journal of Advancement in Life Sciences Research*, *7*(1), 38-44. https://doi.org/10.31632/ijalsr.2024.v07i01.004

Shankar, M. A. (1997). *Handbook of mulberry nutrition*. Department of Sericulture, UAS, Bangalore, and Multiplex, Karnataka Agrochemicals. https://www.biochemjournal.com/archives/2025/vol9issue8/PartK/9-8-69-173.pdf?utm_source=chatgpt.com

Shinde, K. S., Avhad, S. B., Jamdar, S. V., & Hiware, C. J. (2012). Impact of spacing, fertilizer on the productivity of mulberry (*Morus alba* L.) V1 variety. *Life Science Bulletin,* *9*(2), 276-280. https://connectjournals.com/file_full_text/1783902H_275-279.pdf

Subbiah, B. V., & Asija, G. L. (1956). A rapid procedure for the estimation of available nitrogen in soils. *Current Science, 25,* 259-260. https://www.scirp.org/reference/referencespapers?referenceid=2138694

Sudhakar, P., Sobhana, V., Swamy-Gowda, M. R., Kumar, J. S., & Sivaprasad, V. (2018). Soil fertility status of mulberry (*Morus alba* L.) soils under bivoltine sericultural areas of north, south and eastern regions of Karnataka. *International Journal of Advanced Research*, *6*(4), 132-140. https://dx.doi.org/10.21474/IJAR01/6835

Tang, Y., Cui, X., Xu, H., Peng, D., & Liang, B. (2024). Managing Residue Return Increases Soil Organic Carbon, Total Nitrogen in the Soil Aggregate, and the Grain Yield of Winter Wheat. *Agronomy*, *14*(7), 1584. https://doi.org/10.3390/agronomy14071584

Vrajan, V., R., M. Manna, S., Banerjee, A., Pappachan, A., Manjunatha, G. R. M., Chattopadhyay, S., & V. S. (2021). Soil Nutrient Status of Mulberry (Morus species) Growing Fields in West Bengal, India. *International Journal of Current Research, 13*(06), 18058-18066. DOI: https://doi.org/10.24941/ijcr.41768.06.2021

Walkley, A., & Black, I. A. (1934). An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Science*, *37*(1), 29-38. http://dx.doi.org/10.1097/00010694-193401000-00003

Zhang, M. M., Wang, N., Hu, Y. B., & Sun, G. Y. (2018). Changes in soil physicochemical properties and soil bacterial community in mulberry (*Morus alba* L.)/alfalfa (*Medicago sativa* L.) intercropping system. *Microbiologyopen*, *7*(2), e00555. https://doi.org/10.1002/mbo3.555

Zhang, X., Teng, Z., Zhang, H., Cai, D., Zhang, J., Meng, F., & Sun, G. (2021). Nitrogen application and intercropping change microbial community diversity and physicochemical characteristics in mulberry and alfalfa rhizosphere soil. *Journal of Forestry Research*, *32*(5), 2121-2133. https://doi.org/10.1007/s11676-020-01271-y

Zhu, M., Yang, Z., Wang, Z., Tsigbey, V. E., Cui, Z., Zhang, W., ... & Zhao, W. (2025). Mulberry (*Morus alba* L.) planting increased the abundance of soil carbon cycling functional genes by improving soil properties, and further enhanced the stability of soil carbon pool. *Plant and Soil, 515,* 735–751. https://doi.org/10.1007/s11104-025-07621-1