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Effect of Coal Fly Ash and Cyanobacteria on Different Crops

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Abstract
Coal fly ash (CFA), is a byproduct of coal combustion in power plants. However it is known to contain various heavy metals and toxic elements but in recent years, researchers have explored the use of coal fly ash and cyanobacteria as a potential solution to enhance growth of different crops. Rice, Wheat, Barley, Maize, Mustard, Legumes, Vegetables are the important crops worldwide. Growth and yield of crops are essential for food security at international level. The cultivation of these can be affected by various factors including soil quality and nutrient availability. This paper aims to analyse the existing research findings on effect of coal fly ash and cyanobacteria on the growth of different crops and identify knowledge gaps for future research.
Keywords - *Cyanobacteria, Coal fly ash, Biofertilizers, Soil quality, Crops*

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I. Introduction

Use of Coal fly ash is very popular in industrial and infrastructure development related aspects [1]. The use of coal fly ash as a soil improvement in agriculture has gained significant attention due to its potential benefits in improving soil fertility and supporting plant growth [2,3,4]. Cyanobacteria a group of photosynthetic bacteria have been found to possess the ability to fix atmospheric nitrogen and enhance nutrient availability in the soil [5]. Matsumoto *et al* [6]. performed floating cultivation of marine cyanobacteria using coal fly ash. Coal fly ash mixed with cynobacteria can potentially provide a sustainable solution for agricultural practices.

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Several studies have investigated the impact of coal fly ash and cynobacteria on crop growth. In a study performed by Liao et al. it was found that heavy metal stress on Wheat seedlings with and without coal fly ash exposure shows heavy metal deposition on leaves from airborne particulates hinders photosynthesis, weakens the whole physiology of the seedlings and consequently reduces root absorption of heavy metals from soil. [7]

The Ministry of Environment, Forest and Climate Change (MoEFCC), Govt. of India is making continuous efforts for proper ecofriendly dumping and disposal of fly ash . Being nutritionally rich coal fly ash opened doors for its utilization in agriculture rising a tremendous potential in improving crop productivity and soil health. But still, agricultural use of fly ash is quite limited as compared to other sectors of India[8].Fly ash has ability to modifiy the soil health so possess great potential in agriculture. The presence of high concentration of some useful elements in fly ash have ability to increases the yield of many crops but the excess or inappropriate use of fly ash may associated with different problems.[9]

Kumar et al. performed comparative study of fly ash based biofertlizer and chemical fertilizer in wheat and found utilization of fly-ash as carrier in bio-fertilizer formulations as safe and effective alternatives[10]. The study performed by Verma et al.stated that the utilization of fly ash as a carrier in bio-fertilizer formulations is a safe and effective alternative, improving photosynthetic pigments and starch concentration in Wheat plants. The addition of 12% fly ash to the soil, improves crop growth and yield, as well as increased chlorophyll contents. However, increasing concentrations of fly ash led to a decrease in total chlorophyll and carotenoid contents compared to the control. Fly ash incorporation in the soil modified its environment, affecting moisture retention, pH, electrical conductivity (EC) and organic carbon[11].

Upadhyay *et al.* worked on chickpea for sustainable use of fly ash.It was concluded that fly ash supplementation with manure inhances the growth performance, hormones and antioxidant level and

reduces the translocation of toxic metals in the different edible parts of the chickpea (Cicer arietinum L.) plant[12].

Bashir et al.,investigated that the varying levels of fly ash can effect of on the morphological and physiological response (protein content, carbohydrates, chlorophyll and carotenoids) of soyabean Glycine max (L.) Merrill. In his experimental examination it was observed that response boost up to the level of 20 % fly ash from vegetative to pre flowering stage[13].

In a similar study by Mishra & Shukla, plants of maize Zea mays L. and soybean Glycine max L. were treated with fly ash,both crops showed an increase in plant height, metabolic rate, content of photosynthetic pigment and all dry weight fractions measured[14].Rafiullah et al.,observed that in maize plant growth, chlorophyll, and yield content increased with 0% to 40% fly ash (FA), being optimal at 60%. By this it was concluded that fly ash (FA) can be utilized as a substrate or as a soil improving material for the growth of plants, leading to the sustainable utilization of solid waste material[15].Fly ash contains many nutrients, such as Ca, K, Na, Mg, and S, as well as toxic metals such as As, B, Cd, Cr, Hg, and Pb. For utilization of these a phytoremediation technique is used and it was found that varying concentrations of coal fly ash in soil have positive effect on growth of Brassica juncea and Zea mays[16].

During the study conducted with various concentrations of FA (20, 40, 60, 80 and 100%) on the growth and photosynthetic activity of Zea mays (maize) and Oryza sativum (rice) it was observed that plant growth was mostly enhanced in the treatments with 20–40% fly ash, being optimal at 60% thus leading to the sustainable utilization of solid waste material[17].Maragatham et al., found that Rice plants require high quantity of silicate and micro nutrient but their cost is not affordable so coal combustion fly ash is used for soil nutrient management[18]. During the conduction of field experiment rich supply of micronutrients like Zn, Fe, Cu and Mn along with P and K and increased yield were recorded . Effect of different level of fly ash on Paddy studied by Bhavya *et al.*[19].Priatmadi *et al.also* worked on growth and yield of coal fly ash application on Rice with three different type of soil[20].

Tomato plants grown in ash-soil mixture with gradual increase in soil concentrations showed luxuriant growth with bigger and greener leaves (carotenoids and chlorophylls) and yield (flowering, fruiting, fruit weight/plant, mean fruit weight) which in turn improves market value of tomato fruits[21] .

In cereal crop production, biofertilizers such as Rhizobium , Azotobacter, Azospirilium ,cyanobacteria are used to overcome the deficiency of some nutrients due to their fixation in the soil and consequently increase its fertility.Singh et al., conducted the field experiment on Indian mustard *(Brassica juncea*) it was observed that the significant interaction effect between fly ash and nitrogen gives higher seed yield[22].

.Alterary & Marei found that besides being an industrial by-product and being used in cement industry, fly ash can also be used as amended with soil along with fertilizers in different crops when used with some biological component. Fly ash cannot be used as a substitute to soil but when it is amended with soil, increases the pH and water holding capacity of soil. To minimize the disposal of fly ash and maintain the ecosystem, a combination of fly ash, soil and biofertilizer can have positive effect on the productivity of the soil & crop[23].

Khandelwal *et al.*investigated the impact of fly ash on *Rhizobium* bacteria isolated from Legume plants, specifically *Glycine max* and analyze their morphological, cultural and biochemical characteristics. The findings revealed that fly ash in a concentration of 20% did not negatively affect the characteristics of *Bradyrhizobium japonicum*[24].

Kumar and Kumar also worked on use of fly ash for sustainable agriculture in the reference of rhizobial population and yield of legume crops[25].

The study conducted on maize for utilization of fly ash with soil as carrier for Azotobacter biofertilizer and it was found that this utilization lead to increased growth in maize thus also reducing the problem of environmental pollution[26].

Shimaa et al., studied the growth of Maize plants treated with a mixture of coal fly ash ,phosphate solubilizing bacteria (PSB) and cyanobacteria (Cyan.). The results showed a significant increase in plant growth parameters; leaf chlorophyll content, plant height, ear length, ear diameter and ear weight and yield parameters; grain weight, grain yield and straw yield . He suggested that the combination of coal fly ash , PSB and cynobacteria can positively influence crop growth and development[27].

Cyanobacteria, including both heterocystous and non-heterocystous species, have the potential to enhance the growth and productivity of cereal crops like Wheat, Maize, Rice, Barley, Mustard and Legumes through nitrogen fixation and other beneficial effects on soil quality.Being photosynthetic bacteria Cyanobacteria play a significant role in conserving natural resources and sustaining ecosystems responsibly.Optimal integration of cyanobacteria inoculants into farming practices can enhance productivity and ecofriendly agricultural ,environmental sustainability[27,29].

Studies of Singh *et al.* demonstrated role of cyanobacteris as biostimulant in paddy fields[30].

Mohan and Kumar worked on growth performance and yield potential of cereal crops (Wheat, Maize and Barley) in association with cyanobacteria. They found that cyanobacteria also play a considerable role in reducing soil erosion through the secretion of polysaccharides that bind soil, controlling soil runoff and increasing soil organic matter content[31].

Yuan et al.,observed flocculation of cyanobacterial cells using coal fly ash for modified chitosan[32].Rai *et al.*,indicate that large-scale exploitation of cynobacterial inoculants to fly ash in field conditions cannot be made it requires a proper ratio, strain and irrigation facility in the area.The application of cynobacterial inoculant (A. doliolum) enhances the fertility of irrigated fly ash landfills[33].Choudhary et al.conducted their study at rice fields with contaminating thermal Power Stations fly ash .it was found that fly ash accumulation have negative effect on the diversity of cynophyta so they proposed the management of fly ash affected soils with fly ash tolerant *Cyanophyta* species (Anabaena and *Nostoc* sp.) forms for sustainable agricultural practices.[34]

Tripathi et al., found that the accumulation of toxic metals and metalloids in grains in Rice due to contaminated environments is a great matter of growing concern. for this field experiments were conducted for analyzing the growth performance, elemental composition (Fe, Si, Zn, Mn, Cu, Ni, Cd and As) and yield of the rice plants (Oryza sativa L. cv. Saryu-52) grown under different composition of fly-ash mixed with garden soil (GS) in addition with nitrogen fertilizer and blue green algae biofertilizer. the plants growing on integrated use of FA, BGA and NF showed Significant enhancemen for improved growth, yield and mineral composition of the rice plantsas well as reducing the high demand of nitrogen fertilizers[35].Padhy et al. also cultivated Rice with fly ash and cyanobacteria and studied metal load in plant parts[36].In a similar study it was found that cyanobacterial strains (Nostoc muscorum, Anabaena variabilis, Tolypothrix tenuis and Aulosira fertilissimia), as biofertilizers are used with coal fly ash in rice cultivation and observed bioleaching of heavy metals (Cu, Zn, Cr and Pb) to assess utilization of fly ash and thus mitigating its environmental metal toxicity[37].

Furthermore coal fly ash mixed with cynobacteria has also been shown to enhance the tolerance of crops to environmental stress. Study conducted by Similarly in a studied effect of coal fly ash and cynobacteria on the growth of Wheat crops the researchers observed an improvement in the nutrient content of the soil leading to enhanced plant growth and increased yield. Their findings indicate that the utilization of coal fly ash mixed with cynobacteria can have a beneficial impact on crop productivity[38].Vashistha *et al*. performed pot culture experiments to evaluate the impact of fly ash on the growth parameters of Wheat. The highest stimulation was noted at 30%-50% fly ash concentration. Further increase in concentration significantly inhibited the growth parameters[39].Verma and Dubey conducted a pot experiment to study the effect of biofertilizer cyanobacteria (Anabaena and Nostoc) mixed with fly ash on starch content of the wheat plant. Experimental observation revealed the best result in wheat with12% fly ashmixed with 40% of Anabaena and60% of Nostoc. Improvement in the growth of wheat plants was observed. This study revealed that cyanobacteria mixed with fly ash have an excellent potential to increase the Starch content of wheat. This is also helpful in reducing, use of chemical fertilizers in agriculture[40].

Similarly Sharma *et al.* investigated the effect of coal fly ash and cyanobacteria on the growth and nutrient uptake of Mustard plants. The study reported enhanced plant growth nutrient content and enzymatic activities in the treated plants indicating the positive role of cyanobacteria in mitigating the adverse effects of fly ash[41].

III. Conclusion

In conclusion the mixing of coal fly ash and cynobacteria shows promising fertilizer as a sustainable agricultural practice for growth of different crops. Wheat, Maize, Rice, Barley, Mustard and Legumes crops are discussed here in relation to effect of flyash and cyanobacteria as fertilizer. The studies reviewed here demonstrate that this mixture can enhance plant growth, yield, nutrient availability and stress tolerance in these crops. Further research is needed to investigate the long-term effects, potential risks and optimal application rates of coal fly ash mixed with cynobacteria in different agricultural setting aspects such as in terms of seed analysis and heavy metal impact etc.

References

[1]. Bhattacharjee U and Kandpal TC 2002, Potential of fly ash utilization in India. Energy 27 151-166.
[2]. Jala S and Goyal D 2006, Fly ash as a soil ameliorant for improving crop production—a review. Bioresource Technology 97 (9) 1136–1147.
[3]. Khan MW and Khan MR 1996, The effect of fly ash on plant growth and yield of tomato. Environ. Pollution 92 105-111.
[4]. Singh RP, Gupta AK, Ibrahim MH and Mittal AK 2010, Coal fly ash utilization in agriculture: its potential benefits and risks. Reviews in Environmental Science and BioTechnology 9, 345-358.
[5]. Thajuddin N and Subramanian G 2005, Cyanobacterial biodiversity and potential applications in Biotechnology. Current Science 89 (1) 47– 57.

[6]. Matsumoto M, Yoshida E, Takeyama H and Matsunaga T 2000, Floating cultivation of marine cyanobacteria using coal fly ash. In Twenty-First Symposium on Biotechnology for Fuels and Chemicals: Proceedings of the Twenty-First Symposium on Biotechnology for Fuels and Chemicals Held May 2–6, 1999, in Fort Collins, Colorado (pp. 51-57). Humana Press.

[7]. Liao, Z., Xiao, X., Hu, Y., Sun, X., Wang, H., Zhou, H., Ma, Y., & Li, J. (2018). Toxic effects of coal fly ash on wheat seedlings. Environmental Geochemistry and Health, 40(6), 2371–2381. https://doi.org/10.1007/s10653-018-0103-2

[8]. Ch, S., Lakshmi, C., Tripathi, V., Dubey, R., Rani, Y., & Bandla, G. (2019). Fly Ash and Its Utilization in Indian Agriculture: Constraints and Opportunities. https://doi.org/10.1007/978-981-15-0014-5_3

[9]. Zaki A, Siddiqui MK and Lukman A 2022, Effects of fly ash on growth, productivity and diseases of crop plants. Book- Handbook of Fly Ash 525-545. doi: 10.1016/b978-0-12-817686-3.00005-0

[10]. Kumar V, Chandra A and Singh G 2010, Efficacy of fly-ash based bio-fertilizers vs perfected chemical fertilizers in wheat (Triticum aestivum). International Journal of Engineering, Science and Technology, 2(7).

[11]. Verma H and Dubey A 2017, Effect of fly ash application on the chlorophyll content of Wheat (Triticum aestivum). J. Phytol. Res. 27 (1 &2) : 19-23.

[12]. Upadhyay, S. K., Ahmad, M., Srivastava, A. K., Abhilash, P. C., & Sharma, B. (2021). Optimization of eco-friendly novel amendments for sustainable utilization of Fly ash based on growth performance, hormones, antioxidant, and heavy metal translocation in chickpea (Cicer arietinum L.) plant. Chemosphere, 267, 129216. https://doi.org/10.1016/j.chemosphere.2020.129216

[13]. Bashir, S. U., S. R, M., N. A, W., & Ayub Shah, M. (2017). Fly ash induced Morphological, Biochemical and Metal accumulation responses at different developmental stages in Glycine max (L.) Merrill. Revised. IOSR Journal of Pharmacy and Biological Sciences, 12(03), 05–13. https://doi.org/10.9790/3008-1203060513

[14]. Mishra, L. C., & Shukla, K. N. (1986). Effects of fly ash deposition on growth, metabolism and dry matter production of maize and soybean. Environmental Pollution Series A, Ecological and Biological, 42(1), 1–13. https://doi.org/10.1016/0143-1471(86)90040-1

[15]. Rafiullah, Khan, S., Kakar, A., Gulshan, A., Hussain, F., Shah, S., Baloch, A., & Jakrro, M. (2022). Effect of Coal Fly Ash on Seedling Growth, Productivity, Biochemical and Heavy Metals Uptake of Zea mays L. and Soil Characteristics in Semi-arid and Climatic Conditions of Quetta Valley. 2, 119–128.

[16]. Carlile, C., Nadiger Burken, S., & Burken, J. (2013). Effect of Fly Ash on Growth of Mustard and Corn. Biosciences Biotechnology Research Asia, 10(2), 551–557. https://doi.org/10.13005/bbra/1164

[17]. Panda, S., Mishra, L., Muduli, S. D., Nayak, B., & Dhal, N. (2015). The effect of fly ash on vegetative growth and photosynthetic pigment concentrations of rice and maize. Biologija, 61. https://doi.org/10.6001/biologija.v61i2.3143

[18]. Maragatham, N., Chinnasamy, P., Geethalakshmi, V., & Maheswari, M. (2022). Impact Fly Ash on Nutrient Status of Wetland Rice Cultivation. International Journal of Plant & Soil Science, 15–22. https://doi.org/10.9734/ijpss/2022/v34i1130934

[19]. Bhavya VP, Thippeshappa GN, Salimath SB, Alur AS and Kumar SA 2020, Effect of Different Levels of Fly Ash on Biometric Parameters of Paddy. Int. J. Curr. Microbiol. App. Sci 9 (9), 3765-3775.

[20]. Priatmadi, BJ., Septiana, M., & Saidy, A. (2023). Growth performance and yield of rice grown in three different types of soil collected from rice fields with coal fly ash application. Plant, Soil and Environment, 69, 314–323. https://doi.org/10.17221/245/2022-PSE

[21]. Khan, M. R., & Khan, M. W. (1996). The effect of fly ash on plant growth and yield of tomato. Environmental Pollution (Barking, Essex: 1987), 92(2), 105–111. https://doi.org/10.1016/0269-7491(95)00098-4

[22]. Singh, H., Dhillon, B. S., & Kaur, M. (2020). Effect of Different Fly Ash and Nitrogen Levels on Growth and Yield of Indian Mustard (Brassica juncea L.). International Journal of Current Microbiology and Applied Sciences, 9(12), 2057–2062. https://doi.org/10.20546/ijcmas.2020.912.242

[23]. Alterary, S. S., & Marei, N. H. (2021). Fly ash properties, characterization, and applications: A review. Journal of King Saud University - Science, 33(6), 101536. https://doi.org/10.1016/j.jksus.2021.101536

[24]. Khandelwal M, Grover N and Srivastava N 2014, Impact analysis of fly ash on cultural and biochemical characteristics of Bradyrhizobiun japonicum. J. Phytol. Res. 27 (1 & 2): 19-23, 2014

[25]. Kumar K and Kumar A 2022, Empirical use of fly ash for rhizobial population and yield of some legume crops for sustainable agriculture. Biomass Conversion and Biorefinery 1-13.

[26]. Mishra, S., & S., D. (2014). EXPLOITATION AND ASSESSMENT OF FLY ASH AS A CARRIER FOR BIOFERTILIZERS. International Journal of Environmental Sciences, 3, 21–28.

[27]. Shimaa, G., Ghabour, T., Hemeid, N., & Khatab, K. (2020). Impact of Biofertilizers on Maize (Zea mays L.) Growth and Yield under Calcareous Soil Conditions. Egyptian Journal of Soil Science. https://doi.org/10.21608/ejss.2020.45922.1392

[28]. Selvaraj, A. (2023). The Role of Cyanobacteria on Sustainable Agriculture. 5, 522–524.

[29]. Chittora, D., Meena, M., Barupal, T., & Swapnil, P. (2020). Cyanobacteria as a source of biofertilizers for sustainable agriculture. Biochemistry and Biophysics Reports, 22, 100737. https://doi.org/10.1016/j.bbrep.2020.100737

[30]. Singh PK, Kumar A, Yadav MK and Singh S 2022, Cyanobacteria as biostimulants in the paddy fields. Cyanobacterial Lifestyle and its Applications in Biotechnology, 281-306.

[31]. Mohan A and Kumar B 2017, Growth Performance and Yield Potential of Cereal Crops (Wheat, Maize and Barley) in Association with Cyanobacteria. International Journal of Current Microbiology and Applied Sciences 6 (10):744-758

[32]. Yuan, Y., Zhang, H., & Pan, G. (2016). Flocculation of cyanobacterial cells using coal fly ash modified chitosan. Water Research, 97, 11–18. https://doi.org/10.1016/j.watres.2015.12.003

[33]. Rai, U. N., Tripathi, R. D., Singh, N., Kumar, A., Ali, M. B., Pal, A., & Singh, S. N. (2000). Amelioration of Fly-Ash by Selected Nitrogen Fixing Blue Green Algae. Bulletin of Environmental Contamination and Toxicology, 64(2), 294–301. https://doi.org/10.1007/s001289910043

[34]. Choudhary, K. K., Shukla, L. N., & Shukla, C. P. (2011). Species of Cyanophyta Diversity in Fly Ash Affected Rice Fields Along National Thermal Plant. International Journal on Algae, 13(2). https://doi.org/10.1615/InterJAlgae.v13.i2.80

[35]. Tripathi, R. D., Dwivedi, S., Shukla, M. K., Mishra, S., Srivastava, S., Singh, R., Rai, U. N., & Gupta, D. K. (2008). Role of blue green algae biofertilizer in ameliorating the nitrogen demand and fly-ash stress to the growth and yield of rice (Oryza sativa L.) plants. Chemosphere, 70(10), 1919–1929. https://doi.org/10.1016/j.chemosphere.2007.07.038

[36]. Padhy RN, Nayak N, Dash-Mohini RR, Rath S & Sahu RK 2016, Growth, metabolism and yield of rice cultivated in soils amended with fly ash and cyanobacteria and metal loads in plant parts. Rice Science 23 (1), 22-32.

[37]. Kaur R and Goyal D 2018, Heavy metal accumulation from coal fly ash by cyanobacterial biofertilizers. Particulate Science and Technology 36 (4):513-516.

[38]. Ahmed, H. (2019). Effect of Nitrogen-Fixing Cyanobacteria on the Growth of Wheat Crop. 221–225

[39]. Vashistha N and Tejasvi A 2022, Impact of Fly Ash on Growth Parameters of Wheat Through Pot Culture Studies. Journal of science and technological researches 4 (3):17-19
[40]. Verma H, Choubisa, L and Dubey A 2016, Use of fly ash as supplement to biofertilizer: A review. J. Phytol. Res. 29 (1 &2) : 85-91
[41]. Sharma R, Kaushik P and Sharma S 2019, Effect of fly ash and cyanobacteria on growth and nutrient uptake of Mustard (Brassica juncea). International Journal of Chemical Studies 7 (2), 1765-1770.