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ECO-FRIENDLY UTILIZATION OF FLY ASH IN AGRICULTURE: A REVIEW

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ABSTRACT: *Among all the treatments, application of fly ash at 120-180 t ha-1 levels were found beneficial for the plant growth and fresh weight of edible part. However, level higher than 180 t ha-1 was found to reduce growth and other parameters of brinjal. Study shows that the available nutrients present in fly ash are beneficial if fly ash is mixed at certain levels for a particular plant species. Findings of the study, reported, in terms of growth and fresh weight accumulation indicates the beneficial use of fly ash as an eco-friendly nonconventional fertilizer at 120 and 180 t ha-1 levels respectively, and address the problem of land utilization for fly ash disposal. Similarly, 5 to 10% fly ash-soil blending concentrations were found beneficial for the growth and yield of chilli plant. That means fly ash acts as an excellent soil modifier, conditioner and a source of essential nutrients for appreciably improving the texture and fertility with significant increase in crop yield over the control at a particular concentration only and is supportive to plant growth.*

KEYWORDS: Eco-Friendly Utilization, Fly Ash, Agriculture

INTRODUCTION

Since there appears a gap between technology development and transfer at farmer's door step, therefore there seems an urgent need to identify the technological needs of farmers with adequate level of intervention to make the farmers more trained and competent for the use of fly ash at their field. To achieve this goal, adaptive research has to be conducted taking existing technology in to consideration and tailoring it to defined area. Correct dissemination of available technology is extremely important to farmers as well as extension functionaries. We have to look for some real innovations to improve agricultural production through the application of new technologies (Fly ash). It is also being perceived that extension system should play a pro-active role in realization to the farmers for getting first-hand information, farmers' perception, feedback and develop more new appropriate methodologies for diverse farm environment. Strong extension network is required to produce food grain with sustainable development of agriculture in our country. The detailed investigations were carried out on fly ash elsewhere as well as at the Indian Institute of Science. The future poses challenges to the scientists, technologists, engineers towards sound management of fly ash disposal & deposition technologies.

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The problem is not due to lack to technical competence but more of adoption, implementation and better management of improved & appropriate technologies. On the basis of studies carried out on fly ash utilization, it is sighted that uses of fly ash in building construction possess great gains. The attempt should be to consciously reduce environmental damage to ensure more effective management of fly ash which India needs. Fly ash can be used as a potential nutrient supplement for degraded soils thereby solving the solid waste disposal problem to some extent. However, the bioaccumulation of toxic heavy metals and their critical levels for human health in plant parts and soil should be investigated. An ultimate goal would be to utilize fly ash in degraded/marginal soils to such an extent as to achieve enhanced fertility without affecting the soil quality and minimizing the accumulation of toxic metals in plants below critical levels for human health. There are several potential beneficial and few harmful effects of fly ash application.

The study based on short duration experimentation concludes that there is an ample scope for safe utilization of fly ash in combination with chemical fertilizer for improving soil fertility and augmenting yield of both rice and peanut in acid lateritic soil. Thus, fly ash can be incorporated with safe in soil as a soil ameliorates and also source of Ca, Mg and micronutrients particularly in acidic soil. Such utilization of fly ash in an integrated manner can save chemical fertilizer to greater extent. However, the long term effect of use of fly ash in agricultural field on accumulation of micronutrients particularly boron and heavy metals needs investigation. Application of either pond ash or fly ash increased the grain yield of both sunflower and maize significantly. However, application of ash in conjunction with FYM produced the maximum yield. There was no significant difference between fly ash and pond ash treatments on crop yield response. Effect of fly ash application on mechanical composition of soil was significant. Although, fly ash has many benefits as an input material for agriculture applications, in view of the fear in the minds of many (regarding the levels of natural radioactivity in Fly Ash and/ the characteristic presence of some amounts of heavy and toxic elements in it) there may be some cautions which have to be taken for the time being while using Fly Ash in agriculture. From the information available till now, there appears to be not much ground for concern on these accounts (heavy metals, radioactivity etc) however further confirmatory studies at the ICAR centers would be helpful in bringing out recommendations in this field. Meanwhile there appears to be sufficient ground now for the cautious and judicious use of this useful material, which is otherwise being wasted/ underutilized.

Aiken and Heidrich (2015) developed a new national supply model for the Australian coal ash industry to support a range of agricultural enterprises at local, national or global scales, within a long term commitment to agricultural production. Using defined thresholds for maximum chemical concentration and regular testing intervals to ensure environment protection is maintained then combined with condition for application. In separating into an Order and Exemption the threshold limits, suite of chemical or other test attributes, and the methodologies of sampling and testing programs has remained unchanged. All sampling frequencies prior to November 2014 are replicated into the new Order and Exemption with compliance to Australian Standards except a specifically defined sampling frequency is provided as a reduced sampling frequencies if the coal ash generated for land application as a soil amendment. Coal ash Order 2014 (CAO) and Coal ash exemption 2014 (CAE) are available on http://www.epa.nsw.gov.au/wasteregulation/orders-exemptions.htmand.This

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approach addresses a market transformation, from low-value –high volume localized output into a high-value, high-volume nationally distributed fly ash, consequently a unified and national approach to distributing product. In this context the logistics in transport and monitoring and evaluation of material and the end use, will remain important components to establishing the fly ash supply chain to service the potential of a market into the Australian agricultural sector.

Saraswat and Chaudhary (2014), worked on effect of fly ash to improving soil quality and increase the efficiency of crop productivity. The property of Fly ash (FA) has been investigated by several authors. The degree of soil pH change on FA application is dependent on the factors like the difference between the pH of FA and soil, the buffering capacity of soil, and the FA capacity as determined by the amount of CaO, MgO, and $Al2SiO_5$ present. On the addition of 200–400 t/ha of FA to sandy loam soil, a significant development in the permeability, field moisture holding capacity, total transferable bases, as well a reduction in BD and acidity, to the benefit of crop production. FA applications have been observed to correct plant nutritional deficiencies of P and Mn, B, Mg, Mo, S and Zn. While studying P adsorption, fixation and fractions in fluidized bed combustion (FBC)-FA and FBC-FA-amended acidic soil, FA and acidic soils were found to have high P- fixation capacities and mixing of the two was found to resolve the P-fixation problem to a great extent. Overall, the impact of FA on microbial activity is thus inconsistent, but in the majority of FA applications at lower doses or in the presence of other organic amendments, the effect is positive, and at higher doses the activity is reduced, particularly with high-pH ashes.

Srivastava and Kumar (2014) carried out to study the effect of different fly ash amendment levels on growth of green manure crop *Sesbania cannabina* (Dhaincha). Fly ash used in present study was obtained from IFFCO (Indian Farmers fertilizers Cooperative Limited), Phulpur. Fly ash was mixed with garden soil of Botany Department of University of Allahabad, in four different concentrations of fly ash i.e. 0% (control/garden soil), 25%, 50%, 75% and 100%. A portion of the soil-fly ash mixtures was separated for physio-chemical properties. Pre-soaked seeds of *Sesbania cannabina* were sown in their respective pots. Data for germination and survival percentages were taken after 15 and 30 days of sowing, respectively. Data for morphological parameters were taken after 45 days of sowing. Some morphological data were taken after maturity of plants. The control set of garden soil and 25% fly ash exhibited 100% germination and 100% survival. In case of 50% fly ash amended soil germination was 100% while survival was 93.33%. The overall estimation of germination percentages illustrated that it was not much affected by fly ash amendment while survival was greatly affected in case of 100% fly ash. The plants sown in 100% fly ash survived only about 2 months and were with very significantly reduced biomass. The result of present study indicates that the four different amendments tested the amendment level up to 75%, showed no adverse effect on *Sesbania pea* plant growth and this plant could be used in reclamation of fly ash deposited sites.

Raj and Mohan (2014) put forward the approach for improved plant growth using fly ash amended soil. A field experiment performed by using fly ash 0, 25, 75, 100 tonnes/ha, change in physical and chemical properties were studied. Fly ash improves the soil texture, water holding capacity, density, pH, bulk density, porosity etc. by using in different ratio with soil. Fly ash addition to the clayey soil significantly reduced the WHC and bulk density. The

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increase in mobility of nutrients of mixing fly ash to clayey soil was reported because of the increase soil porosity and soil drainage. The fly ash application increased the seed grain yield of kharif and rabi crops during their respective season of growth. The high yield of rice, soybean and black gram in fly ash amended soil also reported. Sun flower plants treated with fly ash exhibited improved growth. Relative growth rate and net assimilation rate increased by over 20% at low fly ash application rate. It is also observed that tomato plant grown in fly ash mixture showed luxuriant growth with bigger and greener leaves.

Thakur *et al.* (2013), physico-chemical characterization of fly ash, three different soils and irrigation water was carried out. The growth of chilli plants was studied in 0%, 2%, 5%, 10%, 15%, 20%, 25% fly ash blended soils.The fly ash was obtained from RPL Urja limited, at Wani in Yavatmal District of Maharashtra (India). Seeds of chili (of make Jwala) were collected from the market. Three different soil samples were taken at 25cm depth from the surface and sampling was carried out by quartering method. These soils were air dried and powdered. These soils were blended with fly ash in% by weight as 0%, 2%, 5%, 10%, 15%, 20% etc. and were kept in clean polyethylene bags. Two seeds of chili were sown in each bag. The experiment was stated in the rainy season, it was observed that among all% blend concentrations of S1, the optimum height (14.5 inch), number of leaves (75), number of flowers (37) and the number of fruits (18) were found at 10% blending concentration. The maximum values of plant height (13.5 inch), number of leaves (60), number of flowers (33) and number of fruits (23) for S1 in winter were found at 10% blending concentration. From the commercial viewpoint, in rainy, winter and summer season the overall maximum number of fruits were found at 5% to 10% blending concentration.

Singh *et al*. May (2011), studied the performance of several crops grown in fly ash amended soil. Fly ash from Chandrapura Thermal Power Station, Jharkhand, India was used to amend soil from fallow land in the proportion of 60, 120, 180 and 240 tons/ha in selected vegetables, and 10, 20, 30, 40, 50% in selected leguminous crops economically grown in the region and performance of individual species has been evaluated. Specific gravity of fly ash sample was 2.21g/cm2 and bulk density was 1.32g/cm2 in dry state and 1.22g/cm2 in wet state. The pH of fly ash sample was observed as 7.56 while that of soil is 6.65. With increasing concentration of fly ash in soil, the pH also increases. The EC of fly ash has been found to 600µs/cm. p H and EC of different concentration of fly ash in soil is shown in below table;

Sample No	Fly ash concentration (%)	pH	EC 600µs/cm
1	0 (Soil only)	6.65	281
2	10	6.72	288
3	20	6.75	296
4	30	6.9	300
5	40	6.91	308
6	50	6.96	358
7	100 (Fly ash only)	7.56	600

Arivazhagan *et al.* (2011) studied the effect of coal fly ash on agricultural crops. Approached the farmers nearby thermal power station areas before the kharif/ravi season and convinced

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them to utilize ash in their fields. Initial soil samples were collected from the respective trial fields before the application of fly ash in the trial fields. Uniform dose of 50 mt/ha ash were applied to all the fields. Immediately after the application of ash the land was ploughed and mixed thoroughly in the soil. Maintained control field also side by side to compare the effect of fly ash on various crops. Then the remaining operation like sowing and other after cultivation practices like weeding, fertilizer application, irrigation and plant protection measures were uniformly followed for both the treated and control fields. Harvesting of crops done separately and yields were recorded. After the harvest, post-harvest soil and grain samples were collected from the control and treated separately. The soil samples were analysed for its physical and chemical properties and grain samples were analysed for its nutrient contents. Standard analytical procedures were followed for the soil, ash and crop analysis. Most of the options of fly ash utilization systematically and explored yet at field level allow restricted level of application, whereas the present study offers a better bulk utilization of thermal power plant waste and also to help in managing the problems of land-uses as well as food security. The result of the study indicates that the four different amendments tested the amendment level up to 75%, showed no adverse effect on Sesbania pea plant growth and this plant could be used in reclamation of fly ash deposited sites. Most of the options of fly ash utilization systematically and explored yet at field level allow restricted level of application, whereas the present study offers a better bulk utilization of thermal power plant waste and also to help in managing the problems of land-uses as well as food security.

Gupta and Paul (2011), studied Fly ash and its impact on Land to examine the salient characteristics of land use pattern of the study area and assess the impact of fly ash on the production of major commercial crops and the cropping pattern. The methodology has been carried out in three steps Pre-field, Field Survey and Post-field. Whole study has been planned and some literature concerned with the topic of the study has been collected and reviewed under pre field where as under field survey questionnaire survey was conducted among agricultural households in order to get an idea about the nature of cropping pattern, crop production, major use of land, nature of irrigation and its problems, input used, problems of fly ash and its probable fall out on the land use and crop production, change in cropping pattern and any change in land use etc. Post field includes the collected data on cropping pattern, land use characteristics, crop production have been arranged in proper tables and represented by suitable diagrams and maps. The result indicate the level of impact of fly ash on the flower cultivation. The vegetation cover has also reduced to 10% with the growth of settlements. A certain percentage of land under flower cultivation is now devoted to paddy cultivation. By this, the agricultural land has increased approximately by 5% during a period of more than 30 years.

Gond, *et al.(*2010), use the fly ash from Chandrapura Thermal Power Station, Bokaro, Jharkhand (India) was used for amending soil at levels 0, 60, 120, 180 and 240 tons ha-1 in which, brinjal *(Solanummelongena*) was grown and elemental residues of amended soil and plant parts were enumerated. Fly ash samples were randomly collected in large plastics bags from dumping sites of 750MW Chandrapura Thermal Power Station (23o75' N and 86o7' E) of DVC in the Bokaro district of Jharkhand state), India and brought to the laboratory at Central Institute of Mining and Fuel Research (CIMFR), Dhanbad. Soil samples of top 15 cm layer were collected from fallow land near fly ash dumping site for amendment and control

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purpose. The fly ash and soil were sun dried for 5 days and passed through 2 mm sieve before making various amendments (manually). Certified seeds of *Solanum melongena* L. (Swarn Pratibha) a perennial plant of *Solanaceae* family were obtained from Birsha Agricultural University, Ranchi, Jharkhand. Crops were harvested between 100-120 days for metal accumulation study. Among all the treatments, application of fly ash at 120-180 t ha-1 levels were found beneficial for the plant growth and fresh weight of edible part in the present study. However, level higher than 180 t ha-1 was found to reduce growth and other parameters of brinjal. This study shows that the available nutrients present in fly ash are beneficial if fly ash is mixed at certain levels for a particular plant species. Findings of the study, in terms of growth and fresh weight accumulation indicates the beneficial use of fly ash as an eco-friendly nonconventional fertilizer at 120 and 180 t ha-1 levels respectively, and address the problem of land utilization for fly ash disposal.

Kishor *et al.* (2010) studied the use of fly ash in agriculture to improve soil fertility and its productivity. Fertilizer or soil amendments has been established after repeated field experiments for each type of soil to confirm its quality and safety. Fly ash amended soil improves soil texture, reduces bulk density of soil, improves water holding capacity, optimizes pH value, increases soil buffering capacity, improves soil aeration, percolation and water retention in the treated zone due to dominance of silt-size particles in FA, reduces crust formation, provides micro-nutrients like Fe, Zn, Cu, Mo, B etc., provides macro-nutrients like K, P, Ca, reduces the consumption of soil ameliorants (fertilizers, lime). Fly ash can also be used as insecticidal purposes and decreases the metal mobility and availability. Reduction in bioavailability of some nutrients due to high pH (generally from 8 to 12), high salinity and high content of phytotoxic elements, especially boron.

Swamy *et al.* (2010), assess the possible impacts of fly ash on edible crops, this investigation examined the changes in growth, biochemistry, cytology, heavy metal content of *Allium Cepa*. Electrostatically precipitated FA obtained from Talcher thermal station, Orissa in an un-weathered condition consists of the following (%): sand 82.0, silt 10.0, clay 8.0, pH 7.0, & the following elements (mg / kg soil) Na 1180, K 3900, P 45.5, Fe 325, Mn 103, Ni 5.8, Co 5.15, Zn 36.0, Cu 5.06, Pb 8.3, Cr 0.0, and Cd 0.0, generating weight amounts of 30 -40% of the used coal. 1x 1 m experimental fields were prepared by repeated ploughings and soil samples were collected for analysis. Equal amount of organic compost (7.5 T/H) was applied to all the fields, watered properly & left for a day. Then fields amended with required concentrations of FA (1,2.5, 5, 10,15 & 0 T/H) by ploughing and control is maintained uniformly without FA application (0T/H).Bulbs of *Allium cepa*were obtained from local Horticulture office & used in this study.100 bulbs / plot, were pre-soaked overnight. The soaked bulbs were sown in the fields so that the distance between the plants & rows is kept as per agronomic practice. The germination counts were recorded. Within uniform time gap period morphological parameters like seedling height, shoot height, leaf number etc were recorded. After harvest the dry weights and fresh weights of plant parts were recorded. Elemental analysis of onion bulb discovered that Na was unaffected, while K and P contents gradually increased but Fe remained unchanged due to FA amendments. Microelements and heavy metals accumulated at higher concentrations in comparison to control. Field experiments carried out with *Allium cepa*grown in FA amendments clearly indicated that growth and yield of the crop was significantly increasing at 5t/h FA. Although, fly ash has many benefits as an input material for agriculture applications, in view of the fear in the

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minds of many (regarding the levels of natural radioactivity in Fly Ash and/ the characteristic presence of some amounts of heavy and toxic elements in it) there may be some cautions which have to be taken for the time being while using Fly Ash in agriculture. From the information available till now, there appears to be not much ground for concern on these accounts (heavy metals, radioactivity etc) however further confirmatory studies at the ICAR centres would be helpful in bringing out recommendations in this field. Meanwhile there appears to be sufficient ground now for the cautious and judicious use of this useful material, which is otherwise being wasted/ underutilized.

Aggarwal *et al.* (2009), worked on utilization of fly ash for crop production and effect on the growth of wheat and sorghum crops and soil properties. Soils from both experimental sites and fly ash used in the study were analysed for their physical and chemical characteristics. Surface soil samples (0-30 cm) of each location were collected, analysed and averaged for sites' characterization. Wheat cultivar, HD- 2285 was tested for four levels of fly ash, i.e., 0, 5, 10 and 20 t/ha and four levels of N, i.e., 0, 25, 50 and 100 kg/ha at Muthiani village. Cultivar, Lok-1 was also grown under same levels of fly ash and nitrogen. N levels for Sorghum (cultivar CSH-1) were 0, 10, 20 and 40kg/ha at both the sites. Fly ash was applied uniformly in the entire experimental field and ploughed to mix it properly in the soil (In the last week of November for wheat and last week of June for sorghum during both the years). Irrigation scheduling, fertilizer application (except N) and intercultural operations were followed as per normal agronomic recommendations. The experiment was laid out in a completely randomized block design with three replications. Above ground biomass and grain yield were recorded at harvest for all treatments. At harvest of crops, surface soil samples (0-30cm) were collected and analyzed for bulk density, saturated hydraulic conductivity, field capacity, permanent wilting point, pH, electrical conductivity, organic carbon, sodium, calcium and available N, P, K as per standard laboratory methods. Grain and biomass yield increased slightly with fly ash and nitrogen application rates. However, yield values at 5, 10 and 20 t/ha fly ash and nitrogen at 25, 50 and 100 kg/ha only showed non-significant values over control. Grain and biomass yields also increased continuously with combined application of fly ash and nitrogen levels and were 11.8 percent and 14.3 percent higher with 20 t/ha fly ash and 100 kg/ ha N level over control with its values of 2.85 t/ha and 9.70 t/ha, respectively. Growth characteristics of sorghum were influenced significantly by increasing levels of fly ash and nitrogen. Highest average plant heights of 162 cm were recorded with 40 kg N + 20 t/ ha fly ash. Test weight of grain was also increased significantly with increasing levels of fly ash. N and fly ash levels also increased the harvest index of sorghum ranging from 21.6 to 29.0 percent with mean value of 24.95 percent.

Yeledhalli *et al*. did the long term field experiments to study in depth the bulk application of fly ash/ pond ash application @ 30-40 t/ha (one time and repeat application) with recommended dose of NPK fertilizers alone or along with FYM @ 20 t/ha was used for cultivation of sunflower, maize and crops in irrigated vertislos in rotation. Field experiment was conducted at Agricultural College Farm, Raichur, Karnataka from 2004 to 2006. Sunflower and maize were the test crops. Fly ash/ pond ash from RSTPS, Shaktinagar were used as amendments. The ash collected from hoppers is designated as fly ash (FA) while the ash collected from settling pond is called as pond ash (PA). These amendment were applied to soil at recommended dose of 30 t/ha with and without organics @ 20 t/ha. In addition 10 t/ha higher than the recommended dose (40 t/ha) was also included to assess its impact on soil

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properties, mobility and transport of toxic heavy metals and radionuclide into food chain. The recommended dose of fertilizers were applied to soil commonly to all treatments. Each year during kharif season experiment was conducted to study the direct effect of application of fly ash/ pond ash on crop growth and yield and soil properties. During rabi season, the residual effect of fly ash/pond ash on the succeeding crop was evaluated Soil, fly ash and FYM: Composite soil samples collected from the experimental site before the start of experiments were analyzed for various parameters by adopting standard methods. Effect of fly ash application on mechanical composition was significant. The sand and silt content increased from 9.2 to 10.0 per cent and from 27.0 to 28.5 per cent respectively. On the contrary, the clay content of soil decreased from 63.8 to 61.6 per cent. The pH, EC and bulk density of soil did not change significantly due to application of either fly ash or pond ash. Soil porosity increased marginally from 50.9 per cent in control to 51.7 per cent due to application of fly ash. The WHC of soil increased significantly.

Basu *et al.* (2008), Potential fly-ash utilization in agriculture: Lime application in agriculture contributes to global warming as Intergovernmental panel on re climate change (IPCC) assume that all the lime in agriculture finally released as CO_2 to the atmosphere. Use of fly ash instead of lime in agriculture can reduce net CO2 emission. The coal ash exemption 2014 commencing 24th November 2014 applies to persons who apply or intend to apply coal ash or blended ash to land for growing vegetation. All sampling frequencies prior to November 2014 are replicated into the new Order and Exemption with compliance to Australian Standards except a specifically defined sampling frequency is provided as a reduced sampling frequencies if the coal ash generated for land application as a soil amendment. Coal ash Order 2014 (CAO) and Coal ash exemption 2014 (CAE) are available on http://www.epa.nsw.gov.au/wasteregulation/orders-exemptions.htmandWithin review of marketing strengths, the option of fly ash supply is general purpose soil amendment commonly purchased through existing agricultural supply companies. This approach addresses a market transformation, from low-value –high volume localized output into a high-value, high-volume nationally distributed fly ash, consequently a unified and national approach to distributing product will be critical for achieving solutions to soil acidity and soil sodicity, both for maintenance in supply and equity in specification. In this context the logistics in transport and monitoring and evaluation of material and the end use, will remain important components to establishing the fly ash supply chain to service the potential of a market into the Australian agricultural sector.

Mittra *et al.* (2003), developed an integrated plant nutrient supply system utilizing the fly ash along with other organic waste like paper factory sludge, farm yard manure crop residue and chemical fertilizer for rice –peanut cropping system. Field experiment was conducted with rice (Oryzaativa) variety IR 36 during the wet season (July, 3-Nivember, 5) followed by peanut (Arachishypogaea) variety JL24 during dry season (February , 4-May, 29). Rice was transported in puddle soil by using 45 days old seedling raised in nursery bed. The seed rate used in nursery bed was 50 kg/ha. The crop was irrigated as and when required to maintain a shallow level of submergence throughout the crop growth period. The peanut seed was sown by seed drill at 90 kg/ha. The crop was irrigated to maintain 75% available moisture in soil. For control of tikka disease fungicide (Dithane M-45) was applied as per recommended dose. Fly ash applied at 10 tonnes/Ha and organic material such as FYM were applied in such a quantity to supply 30 kh N/ha and lime 2 tonnes/ha. Another set of experiment fly ash was

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applied at 5 & 10 tonnes/ha in combined treatment. Fly ash, different organic wastes, and entire dose of chemical fertilizer P and K and half dose of N fertilizer were applied at the time of showing; the remaining half of N fertilizer was top dressed by broadcasting in standing crop after 45 days of plantation. Combined application of FYM, as organic source, FA or lime as amendment and chemical fertilizer improved dry matter production, yield and nutrient uptakes of rice. Application of organic material in combination with the chemical fertilizer helped in increasing nutrient supplying capacity of the soil and thus improve soil fertility. Paper factory sludge combination was similar to FYM combination. The uptake of nutrient Ca, Mg, Mn, Zn, Cu, Co, was increased under the combined application of FYM as compared to CF alone or its combination with organic source. Application of FA at 10 tonnes/ha is estimated to add a meagre amount organic carbon (27kg) but considerable amount of Phosphorous (32 kg) Potassium (25 kg), calcium (33 kg), Magnesium (17 kg), Iron (127 kg), Manganese (2.8 kg), Zink (238 gm) and copper (178 gm). Therefore blending of fly ash with any of the organic material in suitable proportion, form a complete mixture of organic carbon and nutrients essential for augmenting the crop yield.

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