Release of Plant Essential Nutrients from Yagya Ash and Impact on Pea (*Pisum sativum*) Growth

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***Abstract*— *This study investigates the agricultural benefits of Yagya (Agnihotra) by analysing the release of essential plant nutrients from Yagya ash and its impact on the growth of pea (Pisum sativum). Incubation experiments and pot trials with Yagya and wood ash were conducted. Incubation study revealed that all treatments were able to improve the soil fertility. Maximum organic carbon, available phosphorus and available potassium were obtained in treatment YA5 and WA6 (0.93% and 1.05%), YA6 and WA6 (159.04 kg/ha and 215.04 kg/ha) and YA6 and WA6 (280.8 kg/ha and 374.6 kg/ha). Available Sulphur was increased by 14.1 to 140.8 and 3.8 to 33.3-fold in Yagya ash and wood ash treatments. pH and electrical conductivity of the soil increased initially in all treatments and normalized at the end of the incubation study in Yagya ash whereas neutral pH was not attained for wood ash treatments. FTIR characterization of ash shows the presence of carboxylic acids, alkenes and alcohols. No significant changes were observed between the surface morphologies of the ash samples before and after incubation. Likewise, pot trials results revealed that Yagya ash improved the plant growth and yield. Maximum seed germination (73.3%), plant length (78.5 cm), plant biomass (29.2g), nodules (20), pod length of 9.37 cm were observed in treatment T5 (Yagya ash + chemical). Additionally, Yagya ash application with organic and inorganic inputs improved the plant nutrients. Findings suggest that Yagya ash can serve as an effective organic fertilizer, promoting sustainable agriculture by enhancing nutrient availability and plant growth.*

***Keywords*— Yagya ash, organic farming, incubation, wood ash, pea.**

I. INTRODUCTION

Recent increases in crop productivity worldwide have been mainly accomplished by increased chemical fertilizer inputs and if food demand rises in the future, it is expected that this input will rise even more [1]. The realization that the rhizosphere and biosphere have been somewhat neglected in the conventional chemical agriculture makes sustainable agriculture the top focus. The environment, soil health and yield quality have all suffered as a result of the indiscriminate use of agrochemicals in recent decades [2].

A healthy soil is essential for producing healthy crops, which in turn improves human welfare. Soils that are nutrient-deficient and contaminated have a significant impact on plant growth and human health. According to current reports, the majority of Indian soils have low organic carbon contents, less than 0.5 percent as well as other nutritional deficiencies. Searching for economically viable, environmentally sound, technically feasible and accessible approaches is essential to maintaining soil fertility. Replacing synthetic fertilizer with renewable organic sources is one way to potentially address these issues [3]. Managing locally available organic resources has proven to be the best way of action. However, the nutrient content of the organic source and nutrient release behaviour in the soil determine appropriateness of the organic sources. Using incubation studies with soil in its natural environment to examine the pattern of nutrient release is one way to determine the compatibility of any organic source. Furthermore, it is crucial to create a strong, useful and appropriate package of nutrient management employing organic resources for various crops based on data from trials, local conditions and economic viability.

Conventional wood ash that is frequently seen as waste, can be applied to soil as a liming agent and to correct nutrient imbalances or deficiencies in forests [4]. Ash applications have been shown to improve soil nutrient content and microbial activity, mineralization, and nitrification [5,6]. According to studies conducted in the field and in greenhouses, ash treatments have significantly increased the physical, chemical and biological properties of the soil [7,8]. This has also improved the plant growth [9]. However, the conventional wood ash contains heavy metals and other pollutants from the source [10]. Yagya or Agnihotra ash, which is infused with the medicinal qualities of wood and other materials used in Yagya, could be employed to get over this limitation. Yagya ash is known to have a good quantity of soil nutrients. Yagya is a practice that is carried out in many nations worldwide. Despite being an age-old fire ritual, it involves burning dried cow dung, unpolished rice, cow butter and medicinal wood like mango etc. in a copper vessel that is typically shaped like an inverted pyramid. Yagya has been traditionally associated with spiritual and environmental benefits. Yagya ash and fumes from Yagya are beneficial for agriculture, water and air purification, lowering the pathogenicity of bacteria and enhancing the health of living things. In addition to being recognized to support plant growth, this ash is used to treat a wide range of ailments. In certain early trials, it has been shown to reduce pest and insect attack, improve seed germination, and neutralize damaging radiations. However, long-term, in-depth field studies supported by scientific data are still lacking.

Focussing the appropriateness of Yagya ash in supplying plant essential nutrients, an incubation study with Yagya ash and wood ash at different doses was conducted in sandy loam soil. Pot trials at optimum ash dose obtained by incubation study were conducted. The main objectives were i) to quantify and compare the phytoavailable nutrient release from ash at different doses ii) understand the mechanism of release by investigating ash surfaces before after incubation, iii) impact of ash on pea plant growth and yield.

II. MATERIALS AND METHODS

2.1 Collection of soil:

Soil was collected from Agriculture Research Campus fields (29.9038ºN, 77.9975ºE), Haridwar (Uttarakhand) India. The site has a mean annual rainfall of 2136.7 mm and a mean annual air temperature of 10ºC to 38.9ºC. This soil was classified as sandy loam. Soil samples were brought to the laboratory, air-dried and passed through a 2-mm sieve and analysed. The soil was alkaline, low in organic carbon content and in available macronutrients (N, P, K). Available micronutrients (Cu, Zn, Mn, Fe) were present in sufficient amount (Table 1).

TABLE 1
PHYSICO-CHEMICAL PROPERTIES OF SOIL

S.No.	Parameter	Values
1	pH	8.4±0.00
2	Electrical conductivity (dS/m)	0.4±0.00
3	Organic Carbon (%)	0.3±0.01
4	Available Potassium (kg ha^{-1})	59.9±1.82
5	Available Phosphorus (kg ha^{-1})	11.0±0.11
6	Available Sulphur (kg ha^{-1})	23.1±1.44
7	Available Nitrogen (kg ha^{-1})	243.9±0.88
8	Iron (ppm)	12.1±0.14
9	Zinc (ppm)	1.9±0.07
10	Manganese (ppm)	6.8±0.12
11	Copper (ppm)	0.8±0.40

Values represent mean of triplicates, ±represents standard deviation

2.2 Ash production:

Yagya was performed by burning of cow dung (288g), cow butter (141 mL), Homa samagri - a medicinal herbal mixture (224g), unpolished rice in copper vessel known as Hawan kund with chanting of mantra. 65g Yagya ash was obtained after the burning of the content. Likewise, conventional wood ash was also collected from a boiler that used wood collected from nearby area.

2.3 Experimental trials:

2.3.1 Incubation experiments:

Yagya ash and wood ash were incubated in soil for 112 days at natural environmental conditions. Plastic pots were used for the study and 5 kg soil was filled in each pot. Experiment comprised of 15 treatments with Yagya ash and wood ash *i.e.* control (soil without amendment) and soils treated with ashes at different doses including 0.5, 1.0, 1.5, 2.0, 2.5, 5.0 and 10 g/kg soil. Two replicates for every treatment were prepared. Soil sampling was done at 0, 7, 14, 21, 28, 42, 56 and 112 days of incubation. To determine the changes on ash surfaces during the incubation, a different setup was used in disposable plastic cups of 150 ml capacity. These cups were filled with 98 g of dry soil and 2 g of ash. The ash particles were sandwiched between two sheets of nylon mesh (25-µm mesh size) and two equal layers of soil. The ash samples were spread over the nylon mesh with care to ensure maximum soil interaction and to allow the passage of air, soil solution and microbial communities. The 2 ash treatments were replicated twice and prepared separately for collecting ash samples after 112 days of incubation. All the pots were subsequently irrigated with distilled water to maintain 60% of the maximum water holding capacity. Subsamples from the pots were collected to measure available nutrients. Incubated ashes were separated from the disposable plastic pots, homogenized and dried before further surface analysis.

Experimental design

Yagya ash		Wood ash	
Treatments	**Details**	**Treatments**	**Details**
C1	Soil		
YA1	0.5 g/kg Yagya ash + soil	WA1	0.5 g/kg wood ash + soil
YA2	1 g/kg Yagya ash + soil	WA2	1 g/kg wood ash + soil
YA3	1.5 g/kg Yagya ash + soil	WA3	1.5 g/kg wood ash + soil
YA4	2 g/kg Yagya ash + soil	WA4	2 g/kg wood ash + soil
YA5	2.5 g/kg Yagya ash + soil	WA5	2.5 g/kg wood ash + soil
YA6	5 g/kg Yagya ash + soil	WA6	5 g/kg wood ash + soil
YA7	10 g/kg Yagya ash + soil	WA7	10 g/kg wood ash + soil

2.3.2 Pot experiments:

Pot trials were conducted with optimized ash dose obtained by the incubation experiments to investigate the effect of Yagya ash on pea crop. Total nine Treatments with Yagya ash and wood ash including control (C) was with soil only, organic fertilizer (C1), chemical fertilizers (C2), T1 (Yagya ash), T2 (Wood ash), T3 (Yagya ash + organic), T4 (Wood ash + organic), T5 (Yagya ash + chemical) and T6 (Wood ash + chemical) were conducted. Five pea seeds were sown in each pot containing 7 kg soil. Irrigation was done with tap water. Plants were harvested at 90 DAS for crop phenological analysis.

2.4 Analysis of soil and ash:

The pH and Electrical conductivity of soil and ash samples were measured using solid to distilled water ratios of 1:2 and 1:5, respectively. Soil organic carbon (%) was estimated according to the method given by Walkley and Black [11]. Available nitrogen (N), phosphorus (P), potassium (K), sulphur (S) and micronutrients (Cu, Mn, Zn and Fe) in soil was determined according to the methods given by Subbiah and Asija [12], Olsen [13], Merwin and Peech [14], Chesnin and Yien [15] and Lindsay and Norvell [16]. Likewise, total N in ash samples was determined by Kjeldahl method and total P, K, Cu, Mn, Fe and Zn in ash was digested with di-acid mixture HNO_3-$HClO_4$ and analysed further.

2.5 Soil and ash characterization:

2.5.1 FTIR:

Fourier transform infrared spectroscopy (FTIR) analysis was conducted on a PerkinElmer spectrum two spectrophotometer with an attenuated total reflectance (ATR). All the raw and soil incubated ash samples were dried, homogenized and sieved before the analysis. FTIR spectra from 16 scans were recorded in the wavenumber ranged 4000-400 cm^{-1} with a 4-cm^{-1} resolution.

2.5.2 SEM and EDS:

To assess the morphological and chemical compositional changes on ash surfaces during the incubation in soil, scanning electron microscopy-energy dispersive spectroscopy (SEM-EDS) was executed with Flex SEM 1000 (Hitachi). Dried ash samples were coated with the gold dust and were observed under the scanning electron microscope. Every ash sample was examined in multiple areas and locations.

2.6 Plant growth and yield:

2.6.1 Seed germination %:

Seed germination (%) was determined according to the following formula:

$$\text{Seed germination (\%)} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds sown}} \times 100 \quad (1)$$

2.6.2 Phenological observations:

Different phenological characteristics like plant length, plant fresh biomass, nodes, number of nodules, number of pods/plants, and pod length were evaluated. Using a ruler, the length of the shoot and roots was measured in fresh plants from the point closest to the soil's surface to the longest part of the plant tip at maturity. For dry weight, the plant material was oven dried at 70ºC for 48 hours and weighed by using weighing balance.

2.7 Statistics:

Two-way analysis of variance (ANOVA) was conducted by Graphpad prism (version 10.0) to investigate the differences among the treatments.

III. RESULTS AND DISCUSSION

3.1 Characterization of the Yagya ash and wood ash:

The characteristic of Yagya ash and wood ash produced are given in Table 2. Both the ashes had an alkaline pH. Electrical conductivity was higher for wood ash (71.8±0.1) as compared to the Yagya ash (63.8±0.7). Higher content of organic carbon (1.8%), phosphorus (1.2%), potassium (5.2%), sulphur (0.6%), copper (125.3 ppm), manganese (588.7 ppm), zinc (154.4 ppm) and iron (801.7 ppm) was found in Yagya ash as compared to the wood ash. However, Heavy metal content such as cadmium, lead and nickel was higher by 54.9%, 87.1% and 29.1% in wood ash as compared to the Yagya ash. Several previous studies confirmed wood ash as an effective soil improvement material [17]. From the analysis results, it is clear that Yagya ash contains higher amount of plant essential nutrients and could be used as a soil fertilizer and soil conditioner in a better way than wood ash.

TABLE 2
CHARACTERIZATION OF YAGYA ASH AND WOOD ASH USED IN THE STUDY

S.No.	Parameters	Yagya ash	Wood ash
1	pH	11.8±0.17	13.2±0.01
2	Electrical conductivity (dS/m)	63.8±0.65	71.8±0.09
3	Organic Carbon (%)	1.8±0.57	0.4±0.11
4	Total Potassium (%)	5.2±0.69	4.3±0.07
5	Total Phosphorus (%)	1.2±0.03	0.9±0.01
6	Total Sulphur (%)	0.6±0.11	0.2±0.02
7	Total Nitrogen (%)	ND	ND
8	Calcium (%)	8.9±0.06	39.0±0.08
9	Iron (ppm)	801.7±0.58	786.9±0.16
10	Zinc (ppm)	154.4±0.07	52.5±0.23
11	Manganese (ppm)	588.7±0.80	866.4±0.44
12	Copper (ppm)	125.3±0.53	77.4±0.18
13	Cadmium (ppm)	3.7±0.63	8.2±0.15
14	Lead (ppm)	3.3±0.58	25.5±0.71
15	Nickel (ppm)	38.30.58	54.0±0.00

ND = Not Detected, ± denoted standard deviation among the duplicates and triplicates

3.2 Effect of Yagya ash on soil properties:

3.2.1 pH and EC:

The influence of Yagya ash and wood ash on soil pH is given in Figure 1a. On 7th day of incubation soil pH ranged from 8.5 to 8.6 and 8.5 to 8.7 in Yagya ash and wood ash treatments. The soil pH was increased with increase in ash concentration, 0.2 pH unit in Yagya ash treatments (YA7) and 0.3 pH units in wood ash treatments (WA7) @ 10g/kg soil as compared to the control. Wood ash caused more increase in pH as compared to the Yagya ash. Similar, findings reported increased pH with increased ash concentration are reported in some earlier studies [18, 19, 20, 21]. Interestingly, both the ash treatments caused an increase in soil pH for the first seven days. After 7th day of incubation, all treatments exhibited a declining trend in soil pH and on 112th day of incubation pH ranged from 5.8 to 7.6 and 7.7 to 8.2 in Yagya ash and wood ash treatments. The results are in accordance with Błońska et al. (2023), reported an increased soil pH over a short period of time on application of wood ash and the impact was more pronounced with increased dose. According to Ulery et al. [22] this is because the hydroxides, oxides and carbonates of potassium and sodium which are mainly responsible for increasing pH are highly soluble and do not remain in the soil for extended periods of time. In Yagya ash treatments, after incubation period of 112 days soils attain neutral pH. One possible reason behind this could be the presence of more decomposable matter in agnihotra ash as evident from organic carbon content (1.8%). Microorganisms can easily decompose those small organic molecules and produce CO_2, organic acids and ammonium ions and eventually reduce the soil pH. However, in wood ash treatments, pH of soil was declined at 112th day of incubation but not to greater extent and neutral pH was not attained. In treatment WA4, WA5, WA6 and WA7 the pH of soil was higher *i.e.* 8.2 at the end of incubation study, which could be harmful to plant growth, especially for species that can't withstand high pH [21]. Increase in soil pH on application of wood ash results due to the ligand exchange between SO_4 and OH ions [23].

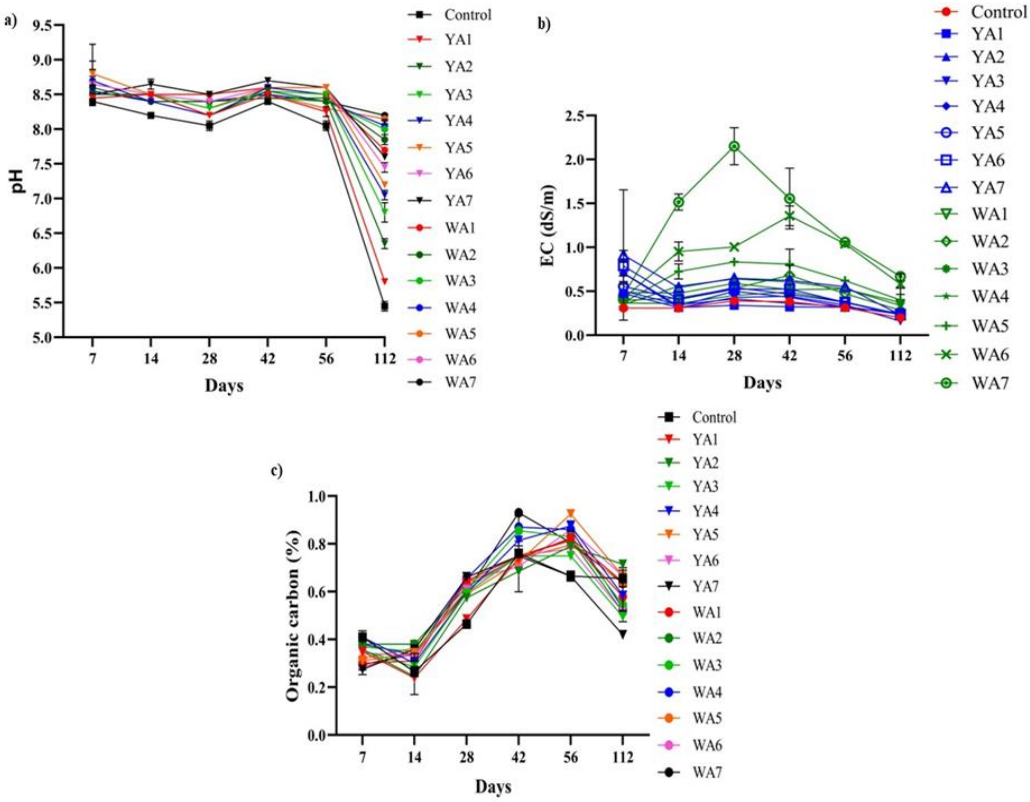

FIGURE 1: Effect of Yagya ash and wood ash on soil a) pH, b) Electrical conductivity and c) Organic carbon %

The influence of Yagya ash and wood ash on soil electrical conductivity (EC) is given in Figure 1b. Soil EC (dS/m) ranged from 0.5 to 0.9 and 0.4 to 2.2 in Yagya ash and wood ash treatments. EC was increased with increase in Yagya ash and wood ash dose in the soil. Similar increase in soil EC was previously reported by An and Park (2021) on application of wood ash. EC of soil treated with Yagya ash was increased till 7th day of incubation and a decline in EC was observed after it. In wood ash treatments, EC was increased till 28th day of incubation and after that a decline in EC was achieved. In Treatment WA7 soil EC was increased to 2.2 dS/m on 28th day of incubation. However, for plant health, EC should not surpass the threshold value of 2 dS/m (Herrero and Pérez-Coveta, 2005), a limit that was not surpassed by rest of the treatments. Though at the end of the incubation study *i.e.* at 112 days all Yagya ash (≤0.2 dS/m) and wood ash (0.2 to 0.7 dS/m) treatments had electrical conductivity of less than 0.50 dS/m, meaning that it did not surpass safety limits except WA6 and WA7. Similar trend in soil EC was reported by Surin et al. [24] in an incubation study with organic fertilizers in paddy soils.

3.2.2 Soil organic carbon %:

The soil organic carbon (%) content in treatments is given in Figure 1c. The organic carbon percent was decreased in all the treatments for first 14 days as compared to the control. OC% was increased after 14th day incubation study till 56th day of incubation with increase in ash concentration and follow the trend of decrease after this. Maximum organic carbon was observed in YA5 and WA6 0.93% and 1.05% treatments on 56th day and 42nd day of incubation respectively. In Yagya ash treatments peak was achieved on 56th day of incubation whereas, in wood ash treatments peak was achieved on 42nd day in treatments (WA4-WA7) and on 56th day of incubation in treatments (WA1-WA3). In all the treatments, ash application was able to improve the organic carbon content of soil. The results are comparable to a recent study by Błońska et al. [27]. Earlier studies have reported that application of wood ash to the soil resulted in carbon having high surface area and high metal oxides contents that can help organic residues to raise C amount in the soil [25, 26].

3.2.3 Soil available macronutrients (N, P, K):

The nitrogen release pattern in different treatments is given in Figure 2a. The results of the whole incubation period indicated that ash treatments are not able to release the sufficient amount of available nitrogen. The findings are comparable to those reported by Błońska et al. [27] and An and Park [21], confirmed the application of wood ash alone might not be sufficient option to compensate N deficiency. Available nitrogen content of soil was observed to be increased with incubation time till 28th day for Yagya ash treatments and till 42nd day of incubation for wood ash treatments.

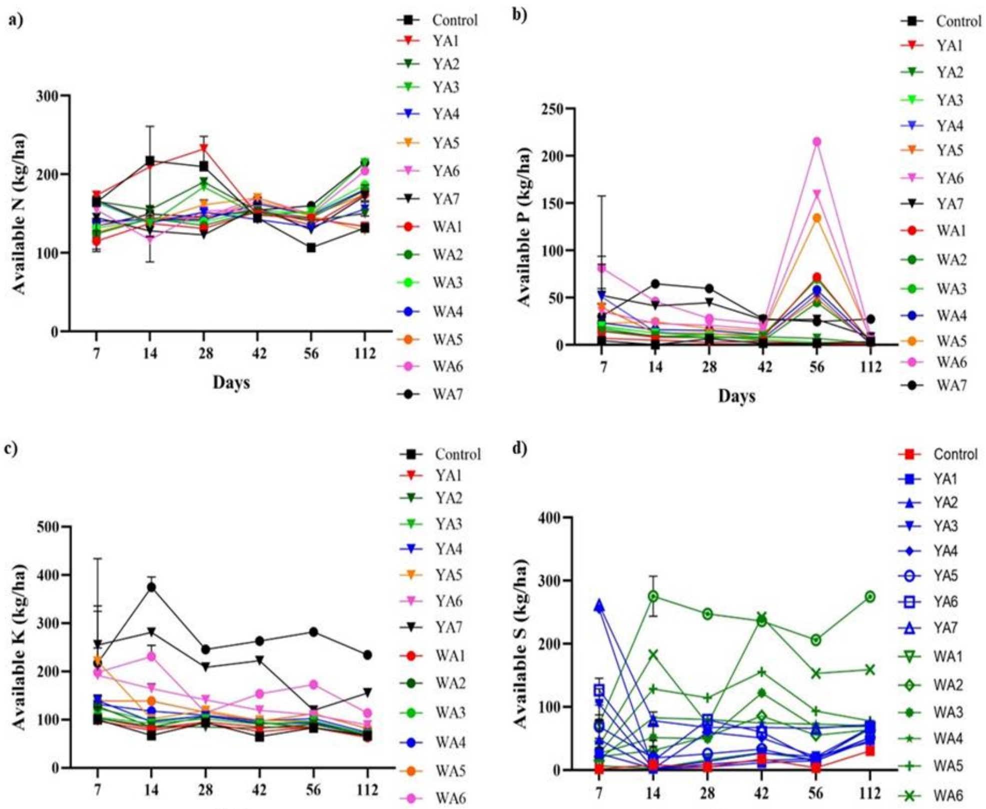

FIGURE 2: Effect of Yagya ash and wood ash on soil nutrients a) Available Nitrogen, b) Available phosphorus c) Available potassium and d) Available sulphur

The phosphorus release pattern in different treatments is given in Figure 2b. When ash treatments were applied to the sandy loam soil, all the ash concentrations released abundant phosphorus except YA1. Available phosphorus content was increased as the concentration of ash increased in both Yagya ash and wood ash treatments. Figure 2b shows a substantial P release by the treatments immediately after application and peak was achieved on 56th day of incubation and later after, all the treatments illustrated a similar diminishing trend. Maximum available P was observed in treatment YA6 and WA6 with 159.04 and 215.04 kg/ha. Likewise, the availability of potassium increased in soil with increase in ash concentration and peak (280.8 kg/ha, 374.6 kg/ha) was achieved on 14th day of incubation in both Yagya and wood ash treatments at concentration of 10g/kg of soil. After 14th day a declined trend was observed in all the treatments. Similar findings were reported in some recent studies [28,21,29].

3.2.4 Soil available sulphur:

Yagya and wood ash were able to supply sufficient amount of sulphur at all the concentrations. The results are comparable with those reported by Baloch et al. [29]. Available sulphur content was increased with increase in concentration. A peak (26.14 to 261.8 kg/ha) was achieved at 7th day of incubation in Yagya ash treatments with 14.1 to 140.8-fold increase in available S as compared to control. In wood ash treatments a peak was achieved at 14th day of incubation with 3.8 to 33.3-fold increase in available S in WA2-WA7 treatments. However, in wood ash treatments WA1 at concentration 0.5g/kg was not able to supply sufficient available S. After peak, a diminished trend was followed in all the treatments.

3.2.5 Soil available micronutrients:

The influence of Yagya and wood ash application on soil available micronutrients is shown in Figure 3. Available copper was increased with increase in ash concentration in both Yagya and wood ash treatments. Peak was observed in treatment YA7 (3.19 ppm) and WA7 (2.05 ppm) at 7th day of incubation. A decrease in copper content was observed after 7th day of incubation in all treatments. All treatments were able to supply sufficient amount of available copper to the soil. The availability of iron and manganese was decreased in all ash treatments as compared to the control (Figure 3c, d). All ash treatments were able to supply sufficient amount of iron except treatment WA1 and WA2. Available iron content was observed to increase till 28th day of incubation and then a diminished trend was followed. The findings are in accordance with Quirantes et al. [30] also reported no change in soil DTPA Fe and Mn on application of different ashes. This might be possible due to soil's hight content of DTPA Fe and Mn [31]. Similarly, the available zinc content was observed to increase with increase in dose in Yagya ash treatments. However, in case of wood ash treatments the Zn content was observed to be decreased in all concentrations. Peak was achieved at 7th day of incubation 1.39 ppm and 1.15 ppm for YA7 and WA1 and a diminished trend was followed after 7th day of incubation.

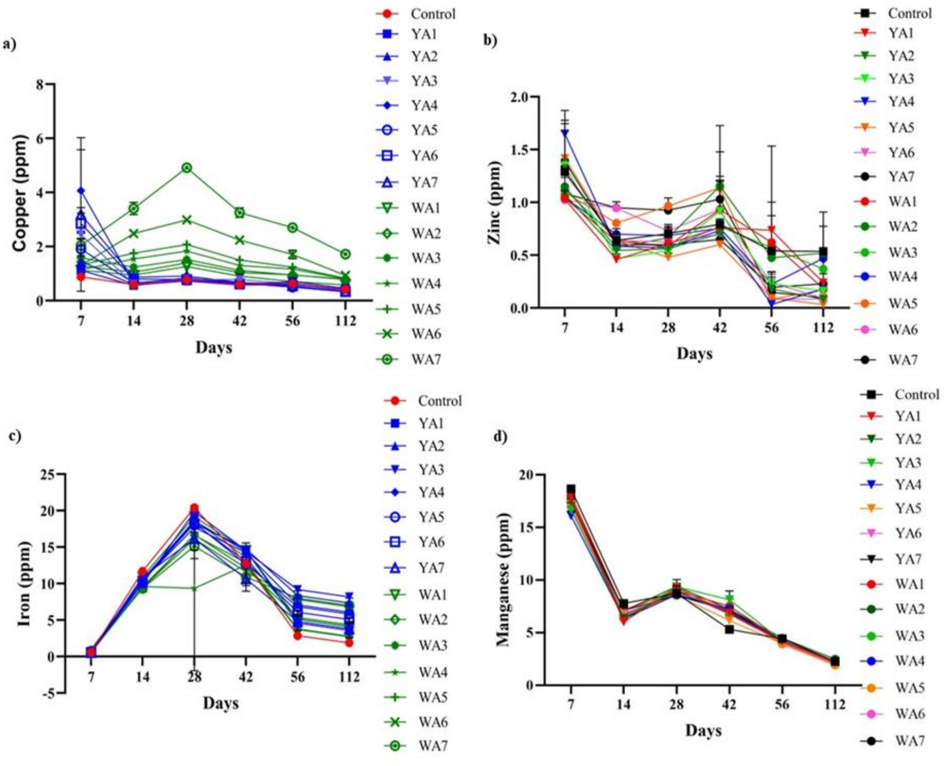

FIGURE 3: Effect of Yagya ash and wood ash on soil micronutrients a) Copper, b) Zinc, c) Iron and d) Manganese

3.3 Changes in ash surface functional groups (FTIR analysis):

The Fourier Transform Infrared Spectroscopy (FTIR) spectra of Yagya ash and wood ash showed numerous peaks between 1460 to 420 cm^{1} (Figure 4a). Peaks in Yagya ash obtained before incubation were 1455, 1035,615, 564, 435 cm^{1} and after incubation were 1415, 1045, 865, 710, 420 cm^{1} respectively. Likewise, for wood ash the peaks were at 1460, 1009, 595, 555 and 435 cm^{1} before incubation and after incubation the peaks were at 1410, 1025, 870, 705, 569, 445 cm^{1}. The absorption peaks in Yagya and wood ash before incubation were showed the functional groups carboxylic acids, alkenes and alcohols. After incubation the peaks represent carboxylic acids, aromatic hydrocarbons and alcohols.

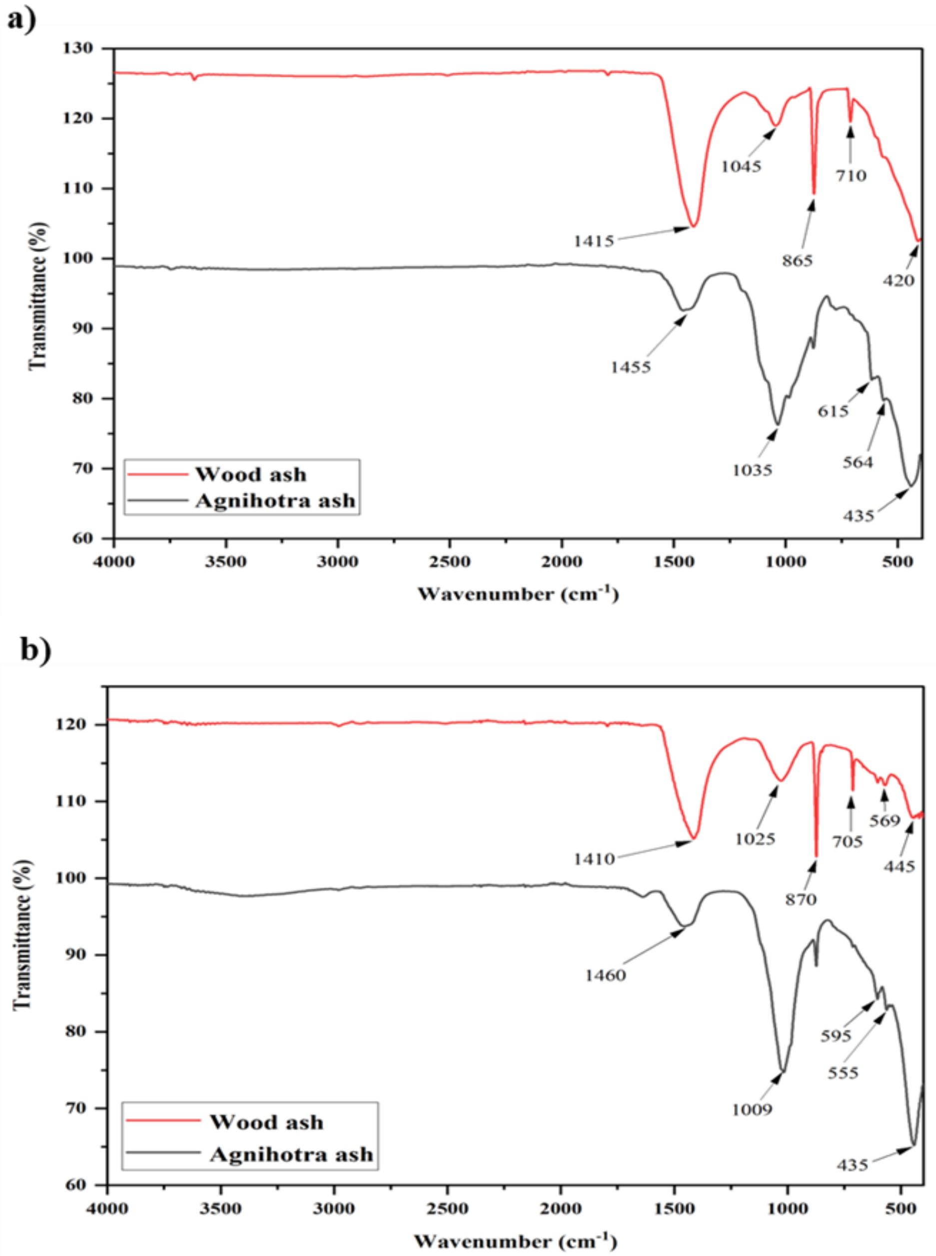

FIGURE 4: FTIR spectra of Yagya (Agnihotra) ash and wood ash a) before incubation and b) after incubation

3.4 Changes in ash surface morphology and elemental composition (SEM-EDS):

The SEM photographs of Yagya ash or agnihotra ash (before and after incubation) and wood ash are depicted in Figure 5. All the ash samples were having in-homogeneous particle sizes and ranged from sub-micron to few microns. Yagya and wood ash particles ranged from 1.24 µm to 21.9 µm, 1.6 µm to 31.2 µm, respectively. From the figure, it is clear that ash particles of both Yagya ash and wood ash were present in aggregated before the incubation study. Generally, no significant changes were observed between the surface morphologies of the ash samples before and after incubation. After incubation the ash aggregate particles were dissolved and separated in small particles. Soil clay particles were observed in the ash samples after the incubation. From EDS micrographs, it is clear that Yagya ash contains elements in higher amount as compared to the wood ash. After incubation, reduction in the content of elements was observed.

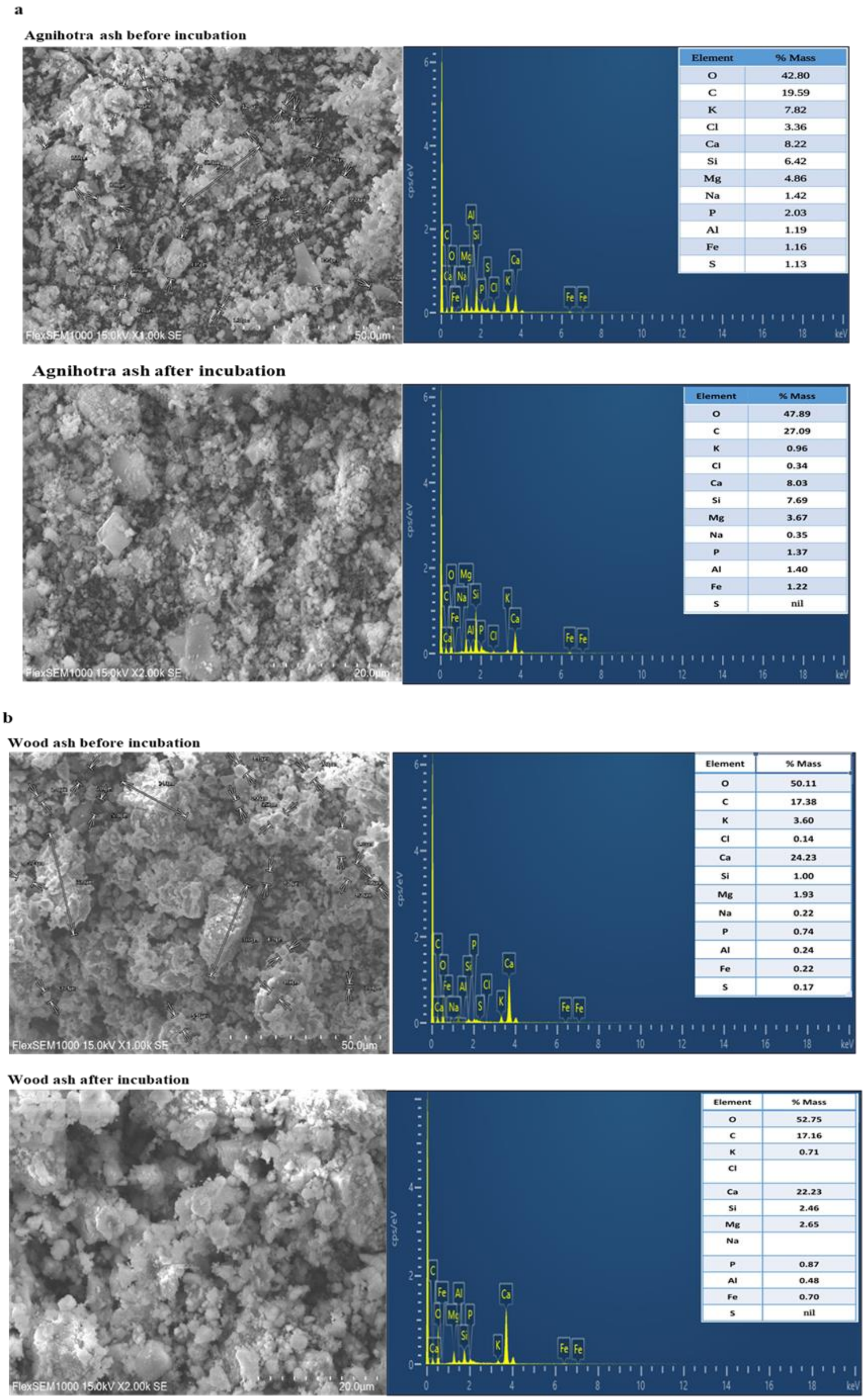

FIGURE 5: Scanning electron micrographs with energy dispersive X-ray spectroscopy a) Yagya (Agnihotra) ash and b) Wood ash before and after incubation

3.5 Effect of Yagya ash on crop phenology

Pea pot trials were conducted with Yagya ash and wood ash at concentration of 2g/kg soil, on the basis of results obtained in incubation study. The germination percent ranged from 53.3 to 73.3 treatments (Table 3). Maximum seed germination of 73.3% was achieved in T2 (wood ash), T3 (Yagya ash + organic) and T5 (Yagya ash + chemical) treatments. Several reports and studies suggest that Yagya ash can enhance seed germination. The minerals in the ash may provide the necessary nutrients for seeds to sprout more successfully. In some instances, it has been noted that seeds treated with Yagya ash exhibit higher germination rates compared to those untreated [32]. According to Singh and Sharma [33] improved soil health supports better water retention, aeration, and nutrient availability could be possible reason for improved seed germination.

The plant growth parameters such as plant length, plant biomass and nodules per plant were maximum with T5 (Yagya ash + chemical) treatment and maximum number of node/plant was observed with T6 (wood ash + chemical) treatment. The application of Yagya ash has been linked to increased crop yields in various studies. For instance, it has been shown to improve the growth of medicinal plants, vegetables and fruit crops [34]. It aids in stimulating root and shoot growth, resulting in healthier and more robust plants.

Yield parameters such as number of pods per plant and pod length was achieved maximum (8.3 and 9.37 cm) with C2 (chemical) treatment and T5 (Yagya ash + chemical) treatment.

TABLE 3
EFFECT OF YAGYA ASH AND WOOD ASH ON PLANT GROWTH

Seed germination and plant growth parameters							
Treatment	**Seed germination (%)**	**Plant Length (cm)**	**Plant Biomass (g)**	**No. of node/plant**	**Nodules**	**No. of pod/plant**	**Pod length (cm)**
C	60	72.5±0.38	16.1±0.69	13.5±0.71	16±0.00	4±0.00	8.8±0.29
C1	70.3	56.5±0.85	11.2±0.43	17±1.41	13.5±0.71	5.7±0.58	8.2±0.87
C2	66.7	68.35±0.97	17.4±0.43	19±1.41	15.5±0.71	8.3±1.15	8.9±0.23
T1	66.7	63.95±0.53	13.4±0.41	18.5±2.12	15.5±0.71	5.0±0.00	8.2±0.35
T2	73.3	62.3±0.49	15.6±0.55	20±1.41	19.5±0.71	5.0±0.00	8.8±0.36
T3	73.3	55.6±0.80	7.9±0.24	20.5±1.41	11.5±0.71	4.0±1.00	9.2±0.78
T4	53.3	67.1±0.62	14.1±0.37	20.5±0.71	13.5±0.00	6.3±0.58	8.8±0.21
T5	73.3	78.5±0.35	29.2±0.49	14±0.71	20±0.71	5.3±1.15	9.4±0.40
T6	60	64.8±0.36	13.0±0.21	22.5±0.71	14±0.00	4.7±1.15	9.3±0.58

TABLE 4
EFFECT OF YAGYA ASH AND WOOD ASH ON PLANT NUTRIENTS

Treatment	**Nitrogen (%)**	**Phosphorus (%)**	**Potassium (%)**	**Sulphur (%)**	**Copper (%)**	**Zinc (%)**	**Manganese (%)**	**Iron (%)**
C	0.21±0.02	0.43±0.00	1.86±0.11	0.89±0.14	10.65±0.05	40.6±0.24	33.96±1.99	229.0±2.60
C1	0.64±0.21	0.49±0.02	1.83±0.05	1.33±0.11	9.56±0.76	40.4±0.06	34.05±0.12	193.2±0.56
C2	0.98±0.01	0.42±0.01	1.89±0.02	1.62±0.11	9.82±0.62	42.4±0.29	38.14±0.28	298.2±0.35
T1	0.20±0.13	0.39±0.01	2.13±0.09	1.92±0.16	9.09±1.02	37.1±0.74	35.61±0.49	388.4±0.82
T2	0.36±0.25	0.29±0.01	1.99±0.03	2.05±0.13	8.98±1.10	35.2±1.26	31.26±1.26	268.3±2.88
T3	2.12±0.02	0.32±0.00	1.85±0.05	2.25±0.07	10.03±0.21	48.4±0.98	35.61±0.04	256.0±1.15
T4	0.54±0.57	0.39±0.01	2.07±0.06	2.37±0.06	9.56±0.35	40.8±0.83	39.64±1.15	213.3±1.05
T5	1.74±0.02	0.32±0.01	2.02±0.05	2.66±0.05	11.18±0.00	39.0±1.11	41.15±1.60	186.0±1.06
T6	1.75±0.30	0.38±0.01	2.09±0.14	2.51±0.02	10.54±0.81	39.6±0.04	36.49±1.03	107.1±0.37

± represents standard deviation among the duplicates and triplicates
(C-Control, C1-Organic, C2-Chemical, T1-Yagya ash, T2-wood ash, T3-Yagya ash+organic, T4-Wood ash+organic, T5-Yagya ash +chemical, T6-Wood ash+chemical)

Impact of different treatments on plant nutrients is summarized in Table 4. From the table, it is evident that application of Yagya ash with both organic and inorganic inputs improved the plant nutrients. Maximum potassium and iron content was achieved in T1 (Yagya ash) treatment. Maximum nitrogen and zinc content was observed in treatment T3 (Yagya ash+organic). Maximum sulphur and manganese content was achieved with treatment T5 (Yagya ash + chemical). Maximum phosphorus content was achieved in C1 treatment (organic).

IV. CONCLUSION

The present study suggest that the ash derived from Yagya positively affects soil fertility, seed germination, plant growth, yield and quality of produce. pH and electrical conductivity of the soil increased in all treatments initially but normalized at the end of the incubation in Yagya ash. In this way, Yagya ash supplies all plant essential nutrients including P, K, S Cu, and Zn without increasing pH and EC of soil. Moreover, application of Yagya ash with both organic and inorganic inputs improved the seed germination, plant growth parameters and plant nutrients. From the results, it is clear that Yagya ash contains higher amount of plant essential nutrients and in moderate dose could be used as a soil fertilizer and soil conditioner in a better way than wood ash and could be used as a booster for organic fertilizers and substitute to the inorganic fertilizers. This study also bridges traditional knowledge and modern science, providing a foundation for further research into agricultural application of Yagya and Yagya ash and more studies should be conducted to explore the effect of Yagya ash on soil microbes and enzymes to elucidate the mechanism lies behind.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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