Effect of Lignite Fly Ash on Germination and Growth of Field Mustard and Sweet Corn

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Abstract:-

Excessive industrialization required more and more electric energy. To get such huge amount of energy, There is need of thermal power power plants. Lignite fly ash is generated as a by-product of coal combustion and 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 this project, the goal is to optimize a phytoremediation technique to stabilize the toxic metals and produce biomass which could have benefit for example as biofuel. The hypothesis was that different amendments would improve the water holding properties of the ash and reduce metals availability and toxicity. Flyash was combined with leaf mulch (1%, , 5%, 10%, 20%), wood mulch (1%, 5%, 10%, 20%), and soil (1%, 5%, 25%, 75%, 90%) in varying concentrations and distributed into 9 "cone-tainers" for each mixture. Water holding capacity was determined for each amendment and the leachates from the cone-tainers were then analyzed to determine pH, EC (electrical conductivity), and TDS (total dissolved solids) for the different mixtures. Zea mays, *Brassicacampestris* and poplar were planted and germination times were recorded. Plants were harvested at 7 weeks for Brassica*campestris* and 8 weeks for Zea mays and biomass and height were recorded. For Brassica *campestris*and Zea mays, plants grew best in soil amendments. For Brassica, leaf mulch appeared to have a negative effect on growth. Further analysis of metal content using ICP-MS is planned**.**

Key words: *Brassica campestris* ,Metals , Phytoremediation, Zea mays.

Intoduction:-

An Aluminium smelter has been operated at NALCO, Angul in Central Odish since 1981 producing primary aluminium by modern Technology. Starting with a capacity of 2,3,0000 Tones of aluminium per annum in 1981 it has increased its capacity to 3,45,000 Tones in 2007 and finaly to 4,60.000 Tones per annum. In case of CPP, it Started in 720MW per Year,in first extention to 960 MW and finaly reached to 1200 MW per year. Fly ash is generated as a by-product of coal combustion (Carlson and Adriano, 1993).. There is a need for a sustainable, low cost method of

remediation because fly ash is produced on such a mass scale and contains toxic elements ((Rautaray *et al*., 2003; Lee *et al*., 2006; Tiwari *et al*., 2008). In addition to the toxic elements, fly ash also contains nutrients which could make it an ideal candidate for phytoremediation (Bilski *et al*. 1995, Bilski *et al*. 2011 . The potential for the produced biomass to be used as biofuel is an added benefit (Pandey, (2009). Fly ash was used as an amendment for agricultural purpose since it consists of valuable elements like K, Mg, S and P and which relate to higher uptake of nutrients and increase in plant growth ((Kalra *et al*., 1997; Singh *et al*., 1997 , (Aitken *et al*., 1984). Fly ash was used to study the growth and other parameters on several plants , to name a few: alfalfa, sorghum (Sorghum bicolor), field corn (*Zea mays*), millet (Echinochloa crusgalli), carrots (Daucas carota), onion (Allium cepa), beans (Phaseolus vulgaris), cabbage (Brassica oleracea), potatoes (Solanum tuberosum) and tomatoes (Lycopersicon esculentum) (Furr *et al*. (1977)), etc

Fly ash amendments: Amendments are additions that increase the quality of the growth medium. They can be soil, organic substances like mulches, compost,etc. Amendments tend to increase crop yield. Fly ash, a granular, fine and glassy texture , when added to such amendments increase the water retention capacity of the growth medium. In our study we dealt with four types of amendments: soil, leaf mulch , flyash and wood mulch.

Soil

Addition of soil to fly ash improves the fertility and the physico-chemical properties of soil such as pH, EC, porosity, water holding capacity, etc (Singh *et al* , 2007, (Khan and Khan, 1996). Singh *et al* (1994) reported that soil amendments increased biomass production.

Rice husk and leaf mulch: Organic matter like ricehusk and leaf mulch is absolutely essential. It binds together soil particles into porous crumbs or granules which allow air and water to move through the soil. Organic matter also retains moisture (humus holds up to 90 percent of its weight in water), and is able to absorb and store nutrients. Most importantly, organic matter is food for microorganisms and other forms of soil life.Flyash improved the soil quality to favour the growth of plant. In Western Australia, improved tree growth has been recorded for orchard trees where 5-6cm was applied as a mulch (Paulin 2000). In India, Panwar and Bhardwaj (2000) showed that farmyard manure when mixed with fly ash showed increase in biomass of trees.

In the present study Fly ash with amendments like soil, rice husk, leaf mulch was tested on plants like *Brassica mcampestris* and *Zea mays* . *Brassica campestris* was chosen because it is known to phytoaccumulate metals (Gupta AK, Sinha S.2006) and *Zea mays* was chosen because it has been previously shown to grow well in fly ash amended soils (Naveen Kalra, 1998).

MATERIAL AND METHODS

Amendments

Several types of fly ash amendment mixtures were prepared by mixing by hand. The following are the mixtures prepared with the percentage of amendment (leaf mulch, woof mulch, flyash or soil) added by weight.

Leaf mulch: 1%, 5%, 10%, 20% Rice husk1%, , 5%, 10%, 20% Soil: 1%, 5%, 25%, 75%,
90%
100% Fly Ash

Leachate Testing

1. Cone-tainers filled with fly ash mixtures were placed over conical centrifuge tubes to catch leaching water
2. 70 mL of water was added to each of the fly ash amendment mixtures
3. The amount of water that leached out and the time taken was recorded.
4. The leachate water was then analyzed for pH, electrical conductivity, and total dissolved solids.

Planting

Fly ash amendments were poured into con-tainers and planted with three different plant types. The two plant types used were *Zea mays* and *Brassica campestris*. For *Zea mays* and *Brassica campestris* plants were grown from seed. There were three replicates of each plant in each mixture. A conical centrifuge tube was placed underneath each cone-tainer to retain some water. Plants were watered as needed. Germination dates were recorded for all plants.

Harvest

. *Zea mays* was harvested at 8 weeks and *Brassica campestris* was h arvested at 7 weeks. The plants were cut off approximately 1 cm above the fly ash amendment. Height and weight were measured for both *Z. mays* and *B. campestris*. For *B. campestris* the number of leaves, pods, and flowers was also recorded.

Metals Analysis

Metals analysis for elements including B, Se, As, Cr, Cu, Mn, Mo, Ni, Pb, V, Zn, Cd, K, Mg, and Na is planned. Plants were first air dried in a hood, and then freeze dried and crushed with mortar and pestle in preparation for digestion with a Multiwave 3000 microwave digester system. Digestion and analysis with ICP-MS is planned.

DATA

Table 1, 2, 3 Graph 1to8

RESULT

Soil amendment

As the soil amendment percentage in fly ash increases from 0-90%, the leaching rate increases from 0.1 ml/min to 2.25 ml/min.

As the fly ash percentage decreases from 90% to 0%, the leaching rate increases from 0.1 ml/min to 2.25ml/min. More the soil in fly ash more the leaching rate. More the fly ash less the leaching rate. Fly ash is able to hold the water containing heavy metals.

Leaf mulch amendment

The leaching rate, when leaf mulch is amended in fly ash, is grossly higher than that of soil amendments. Here too the percentage of leaching rate increases from 0.08 to 9.43 ml/min.

So also, as the fly ash percentage in the leaf mulch amendment decreases from 20 to 0%, the leaching rate increases from 0.08 ml/min to 9.43 ml/min. More the leaf mulch more the leaching rate, more the fly ash less the leaching rate.

Rice husk amendment

The leaching rate in rice husk amendment in fly ash is grossly lower than that of soil amendment. Whether there is an increase or decrease in the percentage of fly ash and rice husk in the mixture from 0-20% , the leaching rate is almost constant at 0.1ml/min.

Germination Data (Fig. 2)

Seeds of *Zea mays* and Brassica when planted in con-tainers containing fly ash and other amendments like soil, rice husk and leaf mulch showed germination after 5 days of planting. Rice husk as an amendment with fly ash showed maximum percentage of seeds germinating. Therefore , in all, Rice husk in combination (any percentage) is best suited for germination of both *Zea mays* and *Brassica campestris*

Leachate analysis

Electrical conductivity, Total dissolved Salts (TDS) and pH decreases as the percentage of soil present in fly ash increases from 0 to 90% or conversely increases as the percentage of fly ash decreases from 90 to 0%. An almost similar trend is seen in case of electrical conductivity, Total dissolved Salts (TDS) and pH of fly ash amended with leaf mulch. But in case of rice husk as an amendment to fly ash, there is slight increase of electrical conductivity and TDS from 0 –20% and slight decrease of pH from alkalinity to acidity.

Harvest Data – *Zea mays* **(Fig 2)**

Plant Height Data: Maize plants grown in soil (90%) amended with fly ash (10%) attain maximum height of 30 cms. In case of leaf mulch (20%) amended fly ash a maximum of 25 cms is attained and least height is observed when plants are grown in rice husk amended with fly ash. Plant Weight Data: 90% soil and 10% fly ash shows a maximum plant weight of 2gms. Leaf mulch (20%) and rice husk(20%) show a reduced plant weight of 1gm and 0.5 gms respectively.

Harvest Data- ***Brassica campestris*** **(Fig. 3) Plant Height Data**

Brassica plants grown in soil (90%) amended with fly ash (10%) attain maximum height of 25cms. In case of leaf mulch (20%) amended fly ash a maximum of 5 cms is attained and least height is observed when plants are grown in rice husk amended with fly ash.
decreases from 90 to 0%. An almost similar trend is seen in case of electrical conductivity, Total dissolved Salts (TDS) and pH of fly ash amended with leaf mulch. But in case of wood mulch as an amendment to fly ash, there is slight increase of electrical conductivity and TDS from 0 –20% and slight decrease of pH from alkalinity to acidity.
leaf mulch amendment decreases from 20 to 0%, the leaching rate increases from8.494 ml/min to 7.6 ml/min. More the leaf mulch more the leaching rate, more the fly ash less the leaching rate.

Rice husk amendment

The leaching rate in wood mulch amendment in fly ash is grossly lower than that of soil amendment. Whether there is an increase or decrease in the percentage of fly ash and rice husk in the mixture from 0-20% , the leaching rate is almost constant at 0.1ml/min.

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Harvest Data – *Zea mays* (Fig 2)

Plant Height Data: Maize plants grown in soil (90%) amended with fly ash (10%) attain maximum height of 40 cms. In case of leaf mulch (20%) amended fly ash a maximum of 3.5 cms is attained and least height is observed when plants are grown in rice husk amended with fly ash. Plant Weight Data: 90% soil and 10% fly ash shows a maximum plant weight of 2.9gms. Leaf mulch (20%) and rice husk (20%) show a reduced plant weight of 1gm and 0.5 gms respectively.

Harvest Data- *Brassica campestris* (Fig. 3) Plant Height Data

Brassica plants grown in soil (90%) amended with fly ash (10%) attain maximum height of35cms. In case of leaf mulch (20%) amended fly ash a maximum of 7 cms is attained and least height is observed when plants are grown in rice husk amended with fly ash. decreases from 90 to 0%. An almost similar trend is seen in case of electrical conductivity, Total dissolved Salts (TDS) and pH of fly ash amended with leaf mulch. But in case of rice husk as an amendment to fly ash, there is slight increase of electrical conductivity and TDS from 0 –20% and slight decrease of pH from alkalinity to acidity.

Plant Weight Data

90% soil and 10% fly ash shows a maximum plant weight of 1.3gms. Leaf mulch (20%) and rice husk (20%) show a reduced plant weight of 0.1gm and 0.2 gms respectively. Number of pods in *Brassica campestris* plants: Brassica plants grown in soil (90%) amended with fly ash (10%) show a maximum of 8 pods per plant. In case of leaf mulch (20%) amended fly ash and rice husk(20%) amended fly ash a maximum of 2 pods and 1 pod respectively was observed..

Table 1 . Leachate Rate

Soil% Amendment	ml/min	Leaf mulch% Amendment	ml/min	Rice husk% Amendment	ml/min
0	0.1219	0	0.0812	0	0.1129
1	0.1434	1	0.0735	1	0.1027
5	0.2249	5	3.0906	5	0.1019
25	0.1509	25	7.5669	25	0.1153
75	0.8848	75	8.5769	25	0.1059
90	2.2505	90	9.4317	90	0.1516

Table 2. Germination Data

	Zea mays		Brassica campestris	
	Germinated/Total planted	Percentage	Germinated/Total planted	Percentage
All soil Amendment	9/50	18%	22/75	29.3%
All Rice husk Amendment	17/50	34%	35/75	46.6%
All Leaf mulch Amendment	10/50	20%	14/75	18.6%

Table. 3.Leachate Analysis

Soil % Amendment	EC AVG	TDS AVG	PH AVG
0	4.269	2.875	8.496
1	4.662	2.929	8.337
5	3.533	2.445	8.019
25	3.830	2.546	7.995
75	1629	1.075	7.398
90	1.292	0.857	7.359
Leaf Mulch % Amendment			
0	4.269	2.875	8.494
1	4.346	2.889	7.495
5	5.899	4.066	5.778
10	0.387	0.268	7.095
20	0.699	0.467	6.808
Rice husk % Amend ment			
0	4.269	2.880	8.497
1	4.165	2.828	8.170
5	5.053	3.378	7.633
10	5.260	3.527	6.516
20	5.115	4.047	6.373

DISCUSSION

Fly ash has been utitlized in agriculture because of its mineral content (Kalra *et al*, 1997, Singh *et al*, 1997). Addition of fly ash in soil has seen increase in plant growth and crop yield in crops like alfalfa, barley, Bermuda grass and white clover (Aitken *et al*, 1997; Weinstein *et al* (1989).

The increased leaching rate associated with higher leaf mulch percentage may have inhibited growth of *B.campestris*. This increased leaching rate may not have affected the *Z. mays* because it puts out a deep taproot which could reach the water retained in the centrifuge tube underneath the cone-tainer.

Adding other amendments rice husk reduces erosion of fly ash (Gorman 2000). Rice huskis

also known to increase dissolved solids and electrical conductivity (Sinha, Gupta 2005). It is may be because of this reason that germination frequency is higher when Brassica and *Zea mays* are grown in wood mulch amendments.

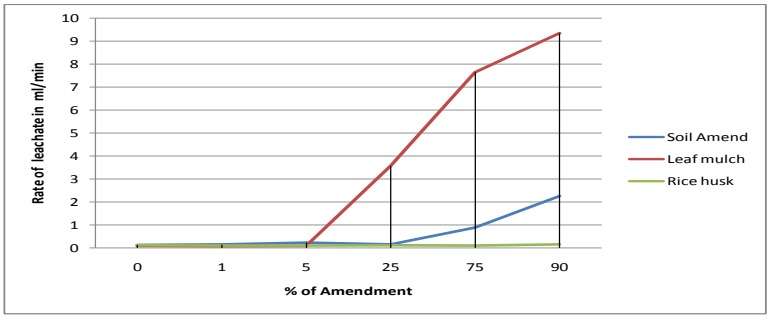
Soil as an amendment with fly ash showed increase in height and no. of pods. It has been reported that there is a increase in the yield of tomato when grown in soil as an amendment of fly ash (Khan and Khan 1996) . Lau and Wong (2001) also showed an increase in plant height when lettuce was grown in 5% fly ash amended with soil.

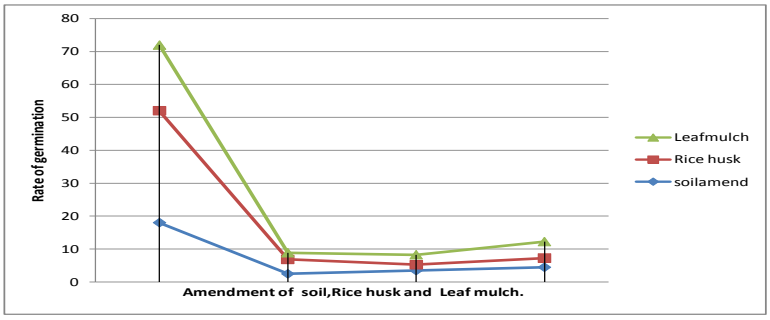
For *Brassicacampestris*, growth appears to be best in plants grown in soil amendments, followed by rice husk amendments, then leaf mulch amendments. For *Zea mays*, plants grew best in soil amendments, followed by leaf mulch amendments, then rice husk amendments.

Conclusion

Fly ash with its amendments like soil, rice husk and leaf mulch have a positive effect on plants like *Brassica campestris* and *Zea mays*. Both *Brassica campestris* and *Zea mays* germinate well in all rice husk amended with fly ash. But soil-amended (90%) with fly ash (10%) produce taller plants, greater mass, more pods and more leaves. Moderate quantities (about 10%) of fly ash when added to soil increases soil fertility and thereby increase the yield of the crops

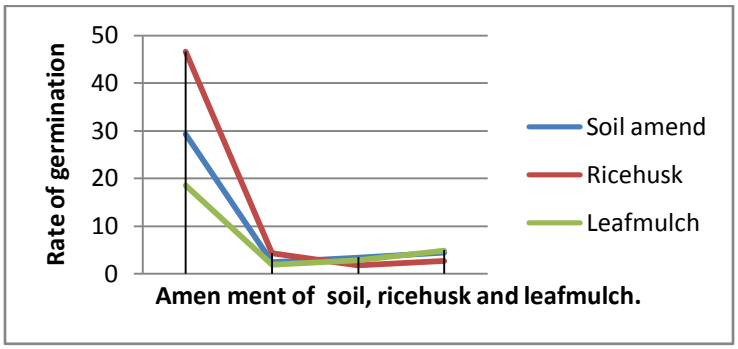
Graph 1:- Rate of Leachate



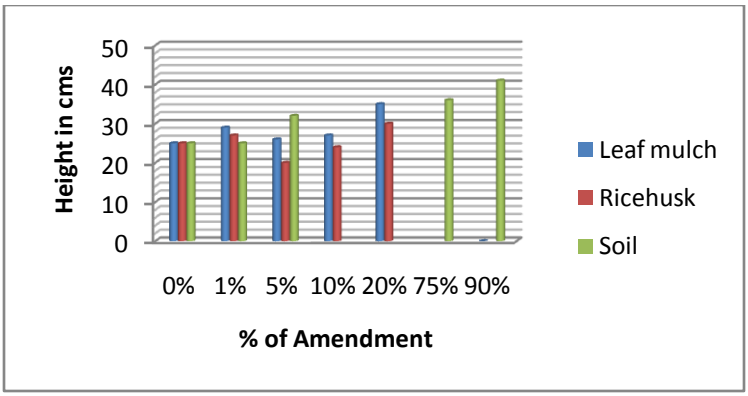


Rate of germination in Zea mays

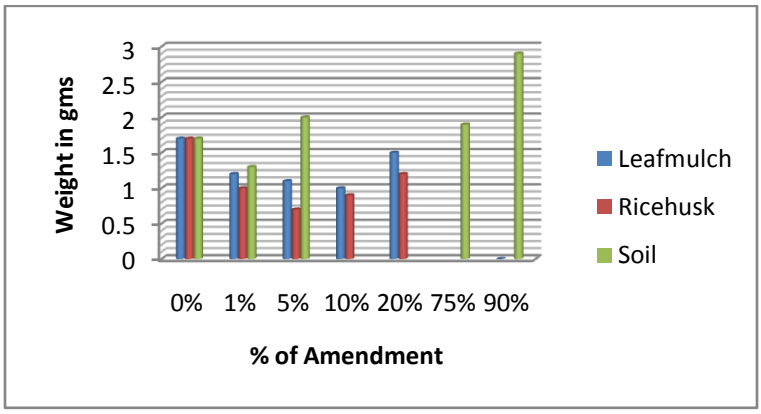
Graph 2:- Rate of germination in Zea mays



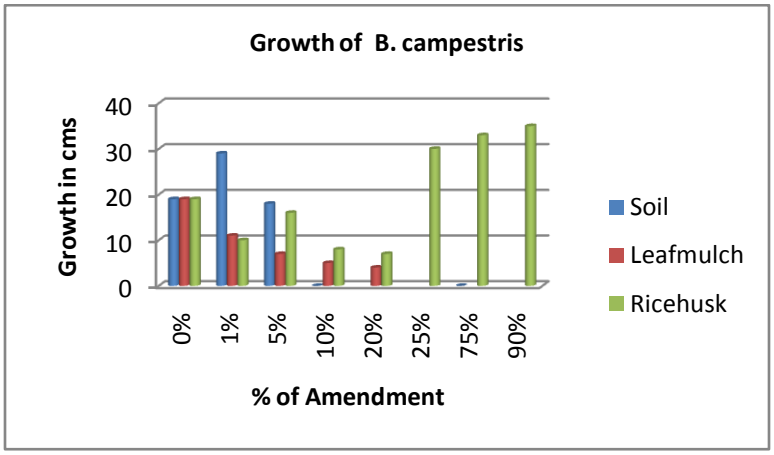
Graph.3. Rate of germination in Brassica campestris



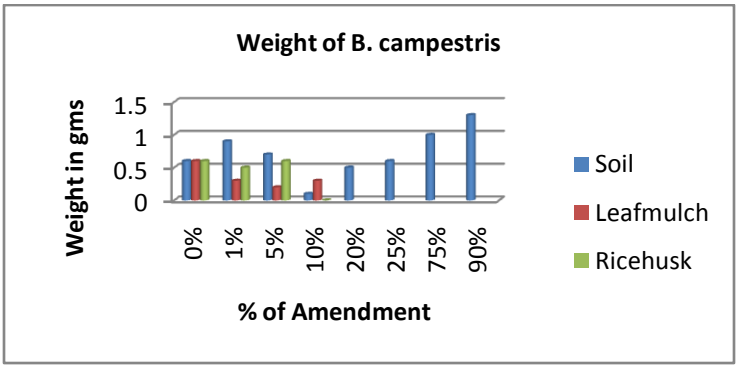
Graph 4 :- Growth of Zea mays



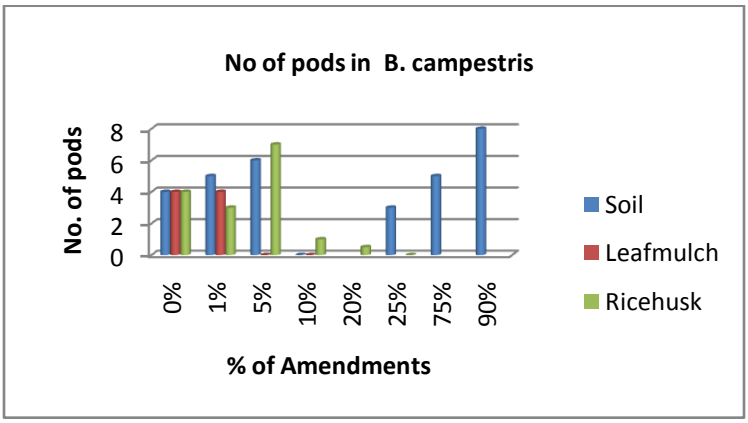
Graph 5:- Weight of Zea mays



Graph 6:- Growth of Brassica campestris



Graph 7:- Weight of Brassica campestris



Graph 8:- No. of pods in B. campestris

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