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Fly Ash Is an Alternative Way to Improve Soil Fertility and Its Productivity

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Abstract
The objective of the study is to investigate physical, chemical, and mineralogical characteristics of fly ash for their potential utilization in agriculture field to reduce use of harmful chemical fertilizers for crop production, The study was conducted with Fly ash of Kota thermal power station, Kota Rajasthan, India. Chemical analysis of fly ash expose that Fly ash is enrich source of many soil vital elements .Fly ash is a byproduct of coal burning in thermal power station. It is a tricky waste residue which create major problems through out the world. Destruction of high amount of thermal byproduct consume a large amount of water, energy and land area and causes many harmful environmental problems , now environmental awareness move towards the proper utilization and management of Fly Ash . However Fly ash is good source of many soil health nutrients, due to its nutritional value it can be used as a supplement of soil health that may improve physical, chemical and biological essence of the soil. The study to improve soil fertility and its productivity with Fly ash amendment was established by pot experiment with monocot and dicot crops ,to reduce the use of harmful chemical fertilizers in agriculture. The work was carried out with an eco-friendly manner. It also reduce the problem of its disposal. Amendment of Fly ash in soil enrich its nutritional value and increase productivity of the selected crop pants. It was found by experiment that amendment of Fly ash up to 70 % and up to 80% increases productivity, but further more amendment decreases growth and productivity of the selected crop plants .Fly-ash has illustrious potential to excel soil fertility and it's productivity . The high concentration of micro nutrients(Cu, Fe, Zn) and macro nutrients (K, Na, Zn, Ca, Mg and Fe) in fly-ash can improve the productivity of monocot plant Wheat (Triticum aestivum L.) and Dicot plant Soybean (Glycine max L.).

Keyword: *Fly ash, macronutrients micronutrients monocot, dicot, soil fertility,productivity.*

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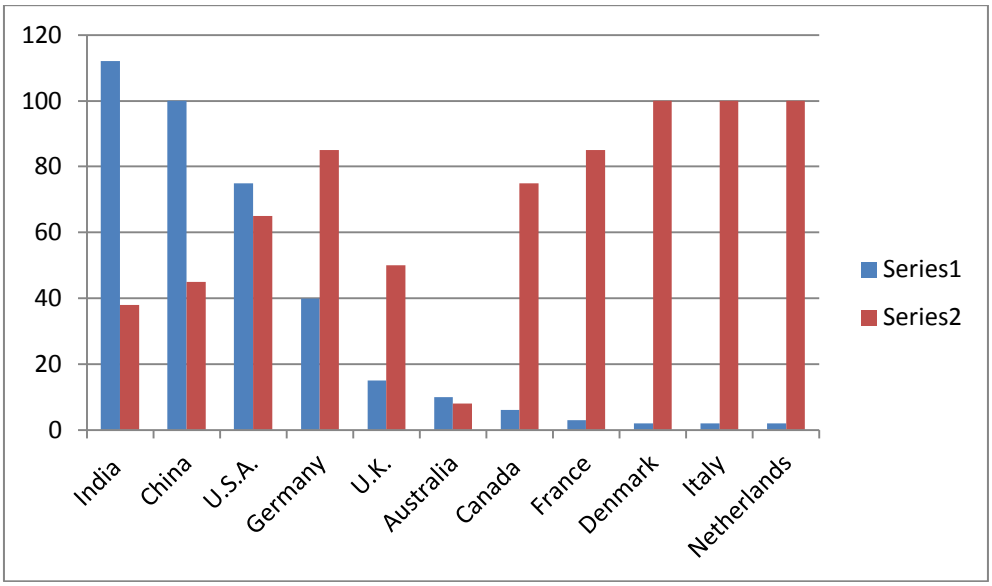
I. Introduction

Thermal power remnants contain Fly ash and base ash. The ratio of both is about 80% and 20% of total Fly ash.

World Wide Fly Ash Production and Its Utilization		
COUNTRY	**PRODUCTION(Mil.Tn/ Yr)**	**UTILIZATION(%)**
India	112	38
China	100	45
U.S.A.	75	65
Germany	40	85
U.K.	15	50
Australia	10	8
Canada	6	75
France	3	85
Denmark	2	100
Italy	2	100
Netherlands	2	100



Production of Fly ash depends on the kind of the coal, The residue of all kind of coal consist a plenty of Fly ash it may be up to 10-30% (Singh and Siddiqui, 2003). In India about 75% of electricity is produced by coal based thermal power stations The amount of Fly ash utilized by different countries is 85% in Germany, 100% in Denmark, 85% in France, 50% in UK, 45% in China and 38% in India. According to Kalra *et al.* (1997) production of Fly ash in India will exceed up to140 million tons during the time of 2020. About 50%-60% of the fly ash is stored at junkyards and ash ravine. The ejection of such a copious amount of FA is one of the major problem and is usually ejected in valley or ravine near the power plants. Fly ash is some times used in buildings, construction of roads, embankment and cement industries ,alkaline nature and a high percentage of mineral substances (micro and macro nutrients) make it's use as soil supplement or as fertilizer to enhance soil health. The FA contains a high ratio of toxic substances such as Cu, Zn, Cd, Pb, Ni, Cr etc. (Lee *et al*., 2006; Tiwari *et al*., 2008) along with low nitrogen and phosphorus. Fly ash can be ejected either by dry or wet methods. In dry disposal, the fly ash is dumped in valley or ravine. In the wet method, it ejected in to the pond ash.

II. Physico-Chemical Effect Of Flyash

The physical and Chemical effect of fly ash (Adriano *et al*., 1980; Carlson and Adriano, 1993) depend on the kind of parent coal, status of combustion , emission and type of control devices and methods of storage and handling .

CHEMICAL CONTENTS OF FLY-ASH

PARAMETERS	FLYASH
p^H	8.1
Ec (dsm^{-1})	0.3
Bulk density(g cm^{-3})	1.39
WHC	67
Particle size	
Sand %	85
Silt %	2.8
Clay%	8.2
Oraganic carbon%	0.29
Available N	26.38
Available P	37.17
Available K	38
Ca	11.6
Mg	1.8
Micro nutrients	
Fe	8.99
Mn	1.43
Zn	0.42
cu	0.13
Boron	0.46
Cd	0.012
Co	0.02
Cr	0.39

OXIDE COMPOUND	VALUES
Sio_2	55.2+-5.2
Al_2O_3	20.5+-2.4
Fe_2O_3	7.1+-4.4
CaO	5.1 +-2.5
MgO	1.5+-0.5
Na_2O	1.6 +- 1.1
K_2O	1.2 +- 0.5

Parameters	Values
Shape of the particle	spherical
colour	Greyish black
Silt (%)	7-8.5
Sand(%)	10 - 88
Clay (%)	1.5-11.2
Gravel(%)	10-25
Moisture (%)	15- 35
Bulk density (g/ cm^3)	1-2.5
Specific gravity (g /cm^3)	1.85-2.70

Composition of Fly ash depends on coal type. In general, fly ash particles are minute and spherical . The base ash settled close to power plant site (Sadasivan *et al*.,1993). Fly ash generated from numerous thermal power station in India contain a ranges of silt 7%-7.8 %, clay 1.5%-11.2%, sand 10%-88% and gravel up to 10%-25%. Bulk density of Fly ash may be from 1 to 1.8 g cm^{-3}. Water Holding Capacity of all kind of FA (WHC) is broadly 50-70 according to weight basis, and moisture 15-35 %. The specific gravity of fly ash ranges from 2.1 to 2.6 g cm^{-3}. Fly ash unusually has high surface area and light texture due to the ubiquity of large, porous and carbonaceous particles.

III. Chemical Effect Of Fly Ash

According to chemical nature, 90-99% of fly ash is consist Si, Al, Fe, Ca, Mg, Na and K . Si and Al compose the major cast (Adriano *et al.*, 1980). There are mainly two types of ash: Class A (low lime) and Class B (high lime) based on silica, alumina and iron oxide content of fly ash. It is substantially rich in trace elements like lanthanum, terbium, mercury, cobalt and chromium (Adriano *et al*., 1980). Many trace elements including As, B, Ca, Mo, S, Se and Sr (Page *et al.*, 1979) in the ash are concentrated in the smaller ash particles (Adriano *et al*., 1980) . The pH of fly ash varies from 5.0 to 12.0 depending on the amount of sulphur content (Plank and Martens, 1974Page *et al*., 1979).

The concentration of various elements in fly ash decreased with increasing particle size (Adriano *et al*., 1978). Chemical constituents of fly ash had a relatively low content of major and trace elements

3.1 **EFFECT OF FLY ASH ON PHYSICAL NATURE OF SOIL**

Fly-ash amendment could permanently alter **soil texture**, increase porosity and improve the water-holding capacity (Ghodrati *et al*., 1995; Page *et al*., 1979). Fly-ash amendment has been reported to alter the texture of sandy and clayey to loamy soil (Capp, 1978). It also improved the **physical properties** of the soil . The particle size of fly-ash also changes the bulk density of the soil. Application of fly-ash with increase percentage (0%,10%,20%...etc) by weight in clay soil remarkably diminish the bulk density and surpass the soil structure, which also surpass porosity, root penetration and moisture-retention capacity of the soil(Kene *et al*., 1991; Prabakar *et al*. 2004) addition of fly-ash up to 46% reduced the dry density of the soil in the order of 15-20% due to the less specific gravity and unit weight of soil. A gradual increase in fly-ash concentration in the normal field soil (0, 10, 20 up to 100% v/v) was noted to increase the porosity and water-holding capacity (Khan and Khan, 1996). This betterment in water-holding capacity is beneficial for the plant growth especially under rainfed agriculture. Amendment with fly-ash up to 40% also improve soil porosity from 43 to 53% and water-holding capacity from 39 to 55% (Singh *et al*., 1997). Fly-ash had been shown to increase the amount of water for plants in the sandy soils (Taylor and Schumann, 1988). Water-retention capacities of fly-ash from various thermal power station in East India were analysed and compared and the effect of partical size associated with water-retention capacity was set on the investigation by Sarkar and Rano (2007).

3.2 EFFECT OF FLY ASH ON CHEMICAL NATURE OF SOIL

Lime which present in fly ash has spoked and reacts with acidic components in soil and releases nutrients such as S, B and Mo in the beneficial way to the crop plants. FA provide good nutrient status to soil. Application of Fly ash increase the pH of acidic soils (Phung *et al*., 1979). Most of the fly-ash produced in, India by Thermal power station is alkaline in nature; hence, its application to agricultural soils could increase the soil pH and therefor neutralize acidic nature of the soil (Phung *et al*., 1978). The hydroxide and carbonate salts of fly-ash make the ability to neutralize acidity in soil (Cetin and Pehlivan, 2007). Fly-ash has been shown to act as a liming material to neutralize soil acidity and provide plant-available nutrients (Taylor and Schumann, 1988). Reports of previous Researchers have shown that the use of fly-ash as liming agent in acid soils may improve soil properties and increase crop yield. The **electrical conductivity** of soil increases with fly ash

application .Metals such as Fe, Zn, Cu, Mn, Ni and Cd also available at higher concentrations in the FA (Gupta *et al*., 2007). The increased accumulation of essential ions such as Zn, Mn and Cu by the paddy shoot/grain might be due to increased activity of ionic transporters (Hall and Williams, 2003), due to higher essential ion availability in the FA. Sarangi *et al*. (2001) observed that gradual increases in **soil pH**, conductivity, available phosphorus, organic carbon and **organic matter** with increased application of fly ash . Fly ash is considered to be a rich source of Si and application of FA in Si-deficient soils has been improve the Si content of rice plants as well as growth of the plants (Lee *et al*., 2006).

Physicochemical Parameters of Fly ash amended soil-

Characteristics	Percentage of Fly ash amendment with soil (v /v)										
	0 %	10%	20 %	30 %	40 %	50 %	60 %	70%	80%	90%	100%
Porosity (%)	28.76	32.54	37.53	39.23	45.6	48.4	53.5	58.21	67.78	75.83	80.33
Moisture (%)	3.12	2.86	2.40	2.15	2.03	1.95	1.74	1.63	1.42	1.34	1.24
Water holding capacity (%)	40.62	42.50	47.42	54.75	61.5	66.2	70.3	73.60	76.15	78.20	85.70
Electric conductivity (ds/m)	3.50	3.76	3.96	4.12	4.76	5.10	5.86	6.01	6.85	7.80	8.60
pH	7.23	7.29	7.32	7.41	7.54	7.63	7.86	7.95	8.31	8.36	8.42
Soluble salt (%)	1.86	1.89	1.92	1.93	1.97	2.30	2.56	2.60	2.62	2.62	2.74
Macro-elements											
Nitrogen	0.28	0.26	0.25	0.26	0.23	0.23	0.21	0.21	0.20	0.19	0.19
Phosphorus	0.203	0.213	0.276	3.12	3.87	4.53	6.30	7.10	7.79	8.20	8.27
Potassium	0.43	0.47	0.51	0.55	0.58	0.62	0.67	0.73	0.79	0.82	0.87
Magnesium	0.091	0.097	0.087	0.09	0.234	0.386	0.410	0.540	0.740	0.884	0.940
sodium	0.92	0.96	0.99	1.04	1.34	1.52	1.74	1.86	1.96	2.04	2.13
calcium	0.27	0.45	0.51	0.65	0.73	0.78	0.94	0.98	1.05	1.12	1.25
Sulphur	2.38	2.30	2.00	2.02	1.98	1.84	1.80	1.72	1.56	1.44	1.42
Aluminium	5.06	5.00	4.45	4.20	4.01	3.89	3.67	3.32	3.10	2.84	2.31
Micro - elements											
Iron	5.21	5.40	5.55	5.70	5.82	5.80	5.87	5.92	6.18	6.35	6.80
Cupper	1.21	1.26	1.30	1.36	1.40	1.47	1.52	1.58	1.61	1.74	1.82
Zink	1.18	1.26	1.32	1.38	1.43	1.46	1.49	1.53	1.57	1.61	1.65

3.3 EFFECT OF FLY ASH ON SOIL PRODUCTIVITY

Utilization of fly ash in agricultural has proposed due to its considerable content of K, Ca, Mg, S and P (Singh *et al*., 1997). Fly ash amendment generally increases plant growth and its nutrient uptake (Aitken *et al*., 1984). Weinstein *et al*. (1989) reported that fly ash increase crop yield of alfalfa (***Medicago sativa***), barley (*Hordeum vulgare*), Bermuda grass (*Cynodon dactylon*) and white clover (*Trifolium repens*). Addition of unweathered western US fly ash up to 8% in the soil responsible for higher yield of several agronomic crops (Page *et al*., 1979) mainly due to better availability of S for the plants. Acording to Furr *et al*. (1977) , alfalfa, sorghum (***Sorghum bicolor***), field corn (*Zea mays*), millet (*Echinochloa crusgalli*), carrots (*Daucas carota*), onion (*Allium cepa*), beans (*Phaseolus vulgaris*), cabbage (*Brassica oleracea*), potato (*Solanum tuberosum*) and tomato (*Lycopersicon esculentum*) could be grown on a minute acidic soil (pH 6.0) . Winter wheat (***Triticum aestivum***) grown on a deep bed of fly ash produced crop which containing higher amount of Seeds (Stoewsand *et al*., 1978). Greenhouse experiments conducted by Sikka and Kansal (1994) showed that application of 2-4% fly ash significantly increased N, S, Ca, Na and Fe content of rice (*oryza sativa*) plants. The foliar application of fly ash also improve growth and metabolic rates, as well as increase the amount of photosynthetic pigments in the crops like maize and soybean (Mishra and Shukla, 1986).

3.4 FLY ASH BRING DOWN THE PRICE OF FARMING

Use of fly-ash in agricultural sector along with chemical fertilizers or without any chemical fertilizer or with/without organic materials can reduced the demand of chemical fertilizer as well as increase soil fertility and its efficiency . According to Mittra *et al*. (2003), integrated use of fly-ash, reduce the demand of costly and harmful chemical fertilizers .Amendment of Fly ash much able to improve soil fertility and crop productivity .

IV. Effect Of Fly Ash On Selected Crop Plants

For the study monocot and dicot plants were selected, monocot wheat (*triticum aestivum L.*) belongs to the family poaceae and soyabean (*Glycine max L.)* belongs to Leguminosae / Fabaceae family, show better results along with Fly ash amendment and maximum results appears at 80 % for wheat and at 70% for soybean but further more amendment of Fly ash produce negative effects.

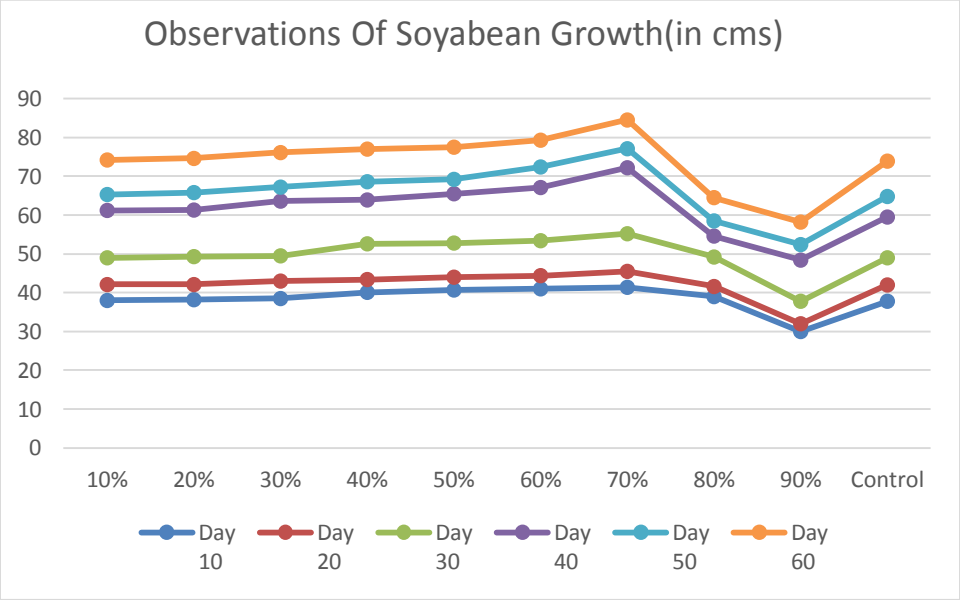
4.1 Material and Method

For the study pot experiment was set up in Govt .College Kota. Fly ash collected from thermal power station, Kota and collection of soil done from non agricultural land. Fly ash amended with the ratio of 10% to 90% with control(100% soil). Measurement of growth done by measuring method with the help of meter scale ,yield were estimated by weighing machine.

4(2)Result and discussion – Observation done regularly with the measurement growth rate and result shows that Fly ash amendment with soil increase the growth parameter but excess use of Fly ash cause harmful effect on plant growth as well as on plant yield. For the selected plant crops maximum results of growth and yield appear at 80 % amendment of Fly ash for wheat (*Triticum aestivum L.*) and for soybean (*Glycine max L*) maximum results appears at 70% amendment .

Observations Of Soybean Growth(in cm)

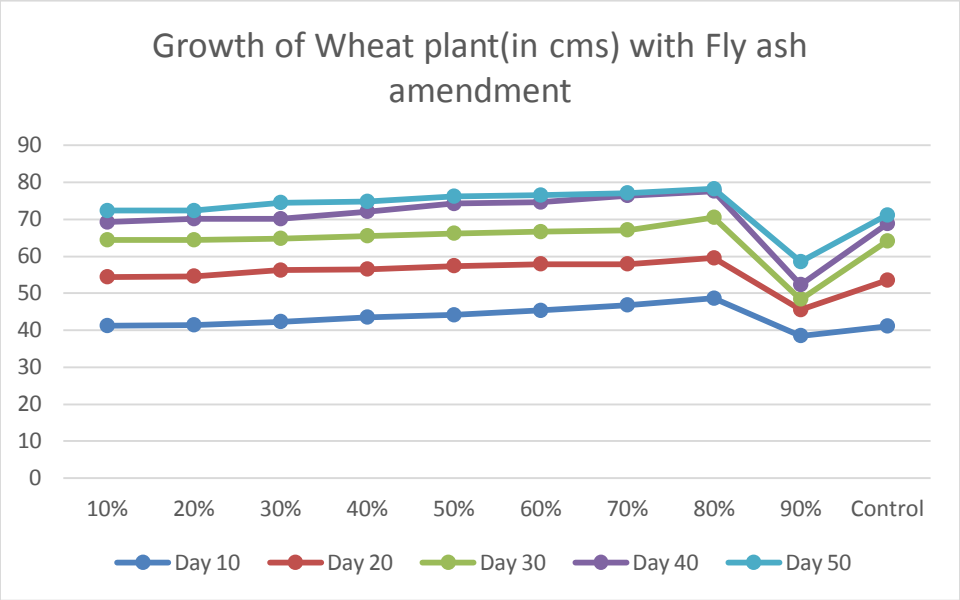
Fly ash	Day 10	Day 20	Day 30	Day 40	Day 50	Day 60	std.dev
10%	38	42.1	49	61.2	65.3	74.2	24.44338
20%	38.2	42.1	49.3	61.3	65.8	74.6	24.54851
30%	38.5	43	49.5	63.6	67.2	76.1	25.14527
40%	40.1	43.4	52.6	63.9	68.6	77.0	25.4112
50%	40.7	44	52.8	65.5	69.2	77.5	25.64408
60%	41	44.4	53.4	67.1	72.4	79.3	26.4806
70%	41.4	45.5	55.2	72.2	77.1	84.5	28.48438
80%	39	41.6	49.2	54.6	58.5	64.5	21.08275
90%	30	32	37.8	48.4	52.4	58.2	19.12389
Control	37.8	42	49	59.5	64.8	73.9	13.94876



Growth of Wheat plant(in cm) with Fly ash amendment

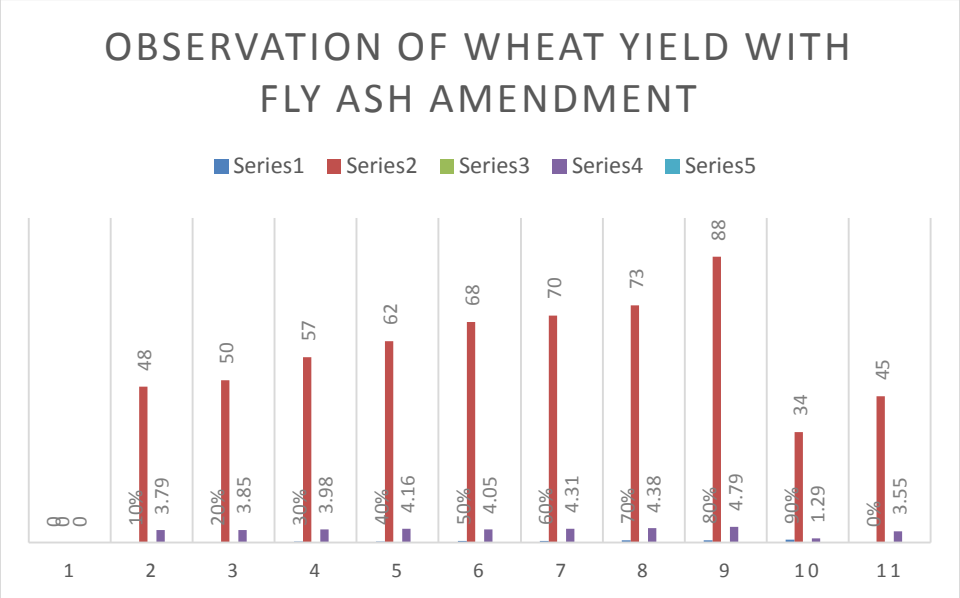
Fly ash	Day 10	Day 20	Day 30	Day 40	Day 50	Std.dev
10%	41.2	54.4	64.4	69.2	72.3	12.64555
20%	41.4	54.6	64.4	70.1	72.3	12.71035
30%	42.3	56.2	64.8	70.1	74.5	12.75292
40%	43.5	56.5	65.5	72.1	74.8	12.74213
50%	44.1	57.4	66.2	74.2	76.2	13.19629

60%	45.3	57.9	66.6	74.6	76.5	12.86573
70%	46.8	57.9	67.1	76.4	77.1	12.86868
80%	48.6	59.5	70.5	77.6	78.2	12.69634
90%	38.5	45.5	48.4	52.3	58.5	7.472483
Control	41.1	53.5	64.1	68.8	71.1	12.41499



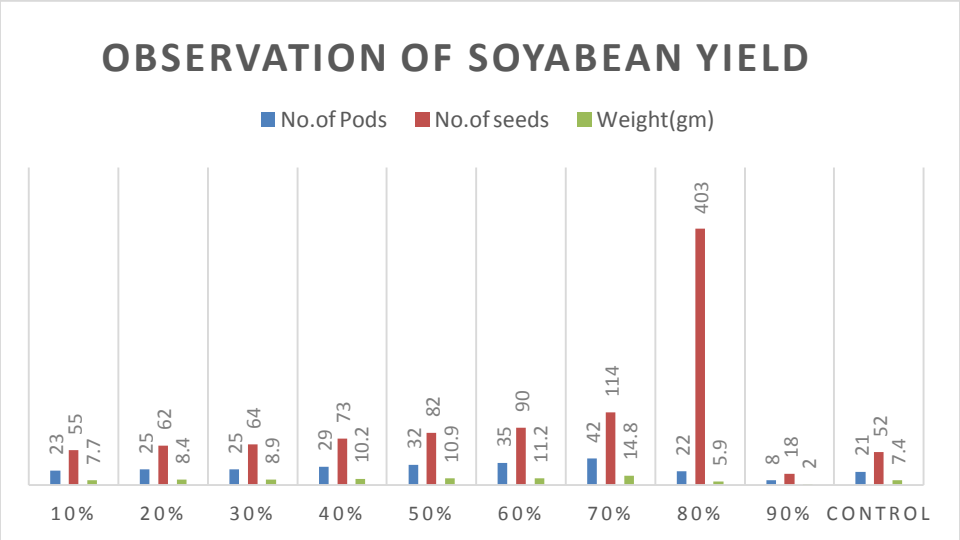
Obsevation Of Wheat Yield with Fly Ash Amendment

Fly ash	No.of Kernels	Weight (gm)
10%	48	3.79
20%	50	3.85
30%	57	3.98
40%	62	4.16
50%	68	4.05
60%	70	4.31
70%	73	4.38
80%	88	4.79
90%	34	1.29
0%	45	3.55



Observation of Soybean yield

Fly ash	No.of Pods	No.of seeds	Weight(gm)
10%	23	55	7.7
20%	25	62	8.4
30%	25	64	8.9
40%	29	73	10.2
50%	32	82	10.9
60%	35	90	11.2
70%	42	114	14.8
80%	22	403	5.9
90%	8	18	2
Control	21	52	7.4



V. Conclusion

Fly ash can be used as a source of soil nutritive supplement. Amendment of Fly ash promote growth parameters of crop plants up to a suitable ratio . Study reval that nature of the soil influence by Fly ash amendment (Inam 2007). Fly ash promote growth rate of the crop plants but higher amount of Fly ash produce harmful effect . Use of Fly ash in agriculture sector is a eco- friendly way to solve environmental problem as well as to solve problem related to Fly Ash disposal. And a worldwide goal for utilize FA with degraded or adverse soils to such an extent for the achieve to enhanced fertility without any adverse effect on human health and environment. There are several potential beneficial and few harmful effects of Fly ash application in soil. With specific amendment adverse effect would be minimize.

FAVORABLE- EFFECTS

(1) amelioration in **soil expression** (2) bring down the bulk density of soil; (3) expand **water holding capacity**; (4) boost up pH value; (5) enhance soil buffering capacity; (6) enhance soil aeration (7) provides micro-nutrients like Fe, Zn, Cu, Mo, B etc.; (8) provides macro-nutrients like K, P, Ca, etc.

ADVERSE- EFFECTS

(1) minimize **bioavailability** of some soil supplements due to increase pH value (8 to 12) (2) increase soil salinity and (3) increased value of some phytotoxic elements such as boron.

References

[1]. Adriano, D.C., A.L. Page, A.A. Elseewi, A.C. Chang and I. Straugham, 1980. Utilization and disposal of fly-ash and coal residues in terrestrial ecosystem: A review. J. Environ. Qual., 9: 333-344.

[2]. Adriano, D.C., T.A. Woodford and T.G. Ciravolo, 1978. Growth and elemental composition of corn and bean seedlings as influenced by soil application of coal ash. J. Environ. Qual., 7: 455.

[3]. Aitken, R.L., D.J. Campbell and L.C. Bell, 1984. Properties of Australian fly ash relevant to their agronomic utilization. Aust. J. Soil Res., 22: 443-454 .

[4]. Capp, J.P., 1978. Power Plant Flyash Utilization for Land Reclamation in the Eastern United States. In: Reclamation of Drastically Disturbed Lands, Schaller, F.W. and P. Sutton (Eds.). Madison, WI., ASA., pp: 339-353.

[5]. Cetin, S. and E. Pehlivan, 2007. The use of flyash as a low cost, environmentally friendly alternative to activated carbon for the removal of heavy metals from aqueous solutions. Colloids Surfaces A: Physicochem. Eng. Aspects, 298: 83-87.

[6]. Chang, A.C., L.J. Lund, A.L. Page and J.E. Warneke, 1977. Physical properties of fly ash-amended soils. J. Environ. Qual., 6: 267-270.

[7]. Ghodrati, M., J.T. Sims and B.S. Vasilas, 1995. Evaluation of flyash as a soil amendment for the Atlantic coastal plain. I. Soil hydraulic properties and elemental leaching. J. Water Soil Air Pollut., 81: 349-361.

[8]. Gupta, A.K., S. Dwivedi, S. Sinha, R.D. Tripathi, U.N. Rai and S.N. Singh, 2007. Metal accumulation and growth performance of *Phaseolus vulgaris* grown in fly ash amended soil. Bioresour. Technol., 98: 3404-3407

[9]. Inam,A.,2001.Use of fly ash in turnip(*Brassica Rappa L.*)Cultivation. Pollut.Res..,26:39-42.Jala,S. and D. Goyal,2006 Flyash as a soil ameliorant for improving crop production- A review . Bioresour Technol.,97:1136-11-47.

[10]. Kalra, N., H.C. Joshi, A. Chaudhary, R. Chaudhary and S.K. Sharma, 1997. Impact of fly ash incorporation in soil on germination of crops. Bioresour. Technol., 61: 39-41.

[11]. Kene, D.R., S.A. Lanjewar and B.M. Ingole, 1991. Effect of application of flyash on physico-chemical properties of soils. J. Soils Crops, 1: 11-18.

[12]. Khan, M.R. and W.N. Singh, 2001. Effects of soil application of flyash on the fusarial wilt of tomato cultivars. Int. J. Pest Manage., 47: 293-297.

[13]. Khan, R.K. and M.W. Khan, 1996. The effect of fly ash on plant growth and yield of tomato. Environ. Pollut., 92: 105-111.

[14]. Lee, H., H.S. Ha, C.H. Lee, Y.B. Lee and P.J. Kim, 2006. Fly ash effect on improving soil properties and rice productivity in Korean paddy soils. Bioresour. Technol., 97: 1490-1499.

[15]. Mittra, B.N., S. Karmakar, D.K. Swain and B.C. Ghosh, 2003. Fly ash-a potential source of soil amendment and a component of integrated plant nutrient supply system. International Ash Utilization Symposium, Centre for Applied Energy Research, Kentuky Univ, Paper No.28, http://www.flyash.info/2003/28mit.pdf.

[16]. Page, A.L., A.A. Elseewi and I.R. Straughan, 1979. Physical and chemical properties of fly ash from coal-fired power plants with reference to environmental impacts. Residue Rev., 71: 83-120.

[17]. Phung, H.T., H.V. Lam, H.V. Lund and A.L. Page, 1979. The practice of leaching boron and salts from fly ash amended soils. Water, Air Soil Pollut., 12: 247-254.

[18]. Phung, H.T., L.J. Lund and A.L. Page, 1978. Potential use of Fly Ash as a Liming Material. In: Environmental Chemistry and Cycling Processes, Adriano, D.C. and I.L. Brisbin (Eds.). US Department of Commerce, Springfield, VA, pp: 504-515. Plank, C.O. and D.C. Martens, 1974. Boron availability as influenced by application of fly ash to soil. Soil Sci. Soc. Am. Proc., 38: 974-977.

[19]. Rautaray, S.K., B.C. Ghosh and B.N. Mittra, 2003. Effect of fly ash, organic wastes and chemical fertilizers on yield, nutrient uptake, heavy metal content and residual fertility in a rice-mustard cropping sequence under acid lateritic soils. Bioresour. Technol., 90: 275-283

[20]. Robinson, T., G. McMullan, R. Marchant and P. Nigam, 2001. Remediation of dyes in textile effluent: A critical review on current treatment technologies with a proposed alternative. Bioresour. Technol., 77: 247-255.

[21]. Sadasivan S., V. Meenakshy, B.S. Negi and K.S.V. Nambi, 1993. Chemical characterization and leaching tests on flyash from a coal fired thermal power plant. Nat Semin on Environmental Aspects of Thermal Power Plants, NTPC, Noida, UP, December 1993.

[22]. Sarangi, P.K., D. Mahakur and P.C. Mishra, 2001. Soil biochemical activity and growth response of rice *Oryza sativa* in flyash amended soil. Bioresour. Technol., 76: 199-205

[23]. Sarkar, A. and R. Rano, 2007. Water holding capacities of flyashes: Effect of size fractionation. Energy Sources, Part A: Recovery, Utilization Environ. Effects, 29: 471-482

[24]. Sikka, R. and B.D. Kansal, 1994. Characterization of thermal power plant fly ash for agronomic purposes and to identify pollution hazards. Bioresour. Technol., 50: 269-273.
[25]. Singh, L.P. and Z.A. Siddiqui, 2003. Effects of flyash and *Helminthosporium oryzae* on growth and yield of three cultivars of rice. Bioresour. Technol., 86: 73-78
[26]. Stoewsand, G.S., W.H. Gutenmann and D.J. Lisk, 1978. Wheat grown on fly ash: high selenium uptake and response when fed to Japanese quail. J. Agric. Food Chem., 26: 757-759.
[27]. Taylor, E.M. and G.E. Schumann, 1988. Flyash and lime amendment of acidic coal soil to aid revegetation. J. Environ. Qual., 17: 120-124.

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