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RESEARCH ARTICLE

EFFECT OF LIGNITE FLYASH AND PRESS MUD ON MAIZE BASED INTERCROPPING SYSTEM

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ABSTRACT

Field experiments were conducted at Annamalai University Experimental Farm, Annamalainagar to evaluate the effects of lignite flyash, press mud and farmyard manure in maize based intercropping system during summer and *kharif,* 2012. The experiments were laid out in split plot design replicated thrice with four main and five sub treatments *viz.,* M_1 - FYM + RDF, M_2 – FYM + LFA + RDF, M_3 – PM + LFA + RDF, M_4 - PM+RDF, S_1-sole Maize, S_2- Maize + Sesamum, S_3- Maize + Black gram, S_4- Maize + Sunflower S_5- Maize + Cow pea and four additional treatments *viz*., I_1-sole blackgram, I_2- Sole cowpea, I_3-sole sesame and I_4-sole sunflower were included separately for comparison. With regard to utilization of industrial wastes, press mud @ 12.5 t ha^{-1} + LFA @ 5 t ha^{-1} + RDF recorded the highest growth and yield components. It was followed by FYM @ 12.5 t ha^{-1} + LFA @ 5 t ha^{-1} + RDF. Addition of LFA @ 5 t ha^{-1} with press mud / farm yard manure @ 12.5 t ha^{-1} proved to be superior, rather than sole application. Among the cropping systems, maize + cowpea intercropping system favourably influenced the growth and yield components of maize such as plant height, LAI, DMP, cob length, cob diameter, number of grains cob^{-1} and grain yield. The lowest values of all growth and yield components were recorded under maize + sunflower/sesamum intercropping systems. The maize + cowpea (S_5) intercropping system with the addition of press mud @ 12.5 t ha^{-1} + LFA @ 5 t ha^{-1} + RDF (M_3) recorded the highest grain yield 5831 kg ha^{-1} in summer and 6141 kg ha^{-1} in Kharif, 2012. The uptake of nutrients was found to be significantly higher in industrial wastes application with maize + cowpea intercropping system. The post harvest soil available N, P_2O_5 and K_2O were lower under the same treatment (Press mud @ 12.5 t ha^{-1} + LFA @ 5 t ha^{-1} + RDF (M_3 S_5). The same combination registered the highest return $rupee^{-1}$ invested and BCR of 3.17 and 3.34 in summer and kharif season2012, respectively. Hence, from the results, it is concluded that when maize is grown with the addition of press mud @ 12.5 t ha^{-1}+ LFA @ 5 t ha^{-1} + RDF, and intercropped with cowpea is an economically feasible eco friendly approach to realize better returns for maize growers.

INTRODUCTION

Maize is one of the most important cereal crops in the world's agriculture economy both as food for men and feed for animals. The crop has high yield potential, wider adaptability, grown throughout the world and therefore it is called *"Queen of cereals"*. Maize grain contains about 11.1 per cent protein, 4.0 per cent oil, 66.2 per cent carbohydrate, and 2.7 per cent crude fibre. At Present, maize occupies an area of 138.89 million hectares with a production of 602.02 million tonnes in the world. In India, it occupies an area of 6.56 million hectares with a production of 12.0 million tonnes annually. The average productivity of maize in the world is 4.33 tonnes ha^{-1}, whereas it is only 1.84 tonnes ha^{-1} in India. In Tamil Nadu it is cultivated in an area of 0.12 million hectares with an annual production of 0.19 million tonnes (Anon, 2010). Today, it is necessary to emphasize that the *'wastes are resources'* and therefore their management and utilization is a must be in an eco friendly approach. The exponential increase in industries not only consuming larger area of agriculture land, but simultaneously causing serious environmental degradation of natural resources. Wastes originating from industries like sugar mill industries (press mud), pharmaceutical industry waste and thermal power units (LFA) are finding their place in today's agriculture. Farm wastes such as farmyard manure, which contains an array of plant nutrients, but they cannot be supplied throughout the country because of transport facilities and its odour. The sources of organic matter are scarce, due to shortage and non availability of labour to rear animals. In view of the cost factor, there is an imperative need to utilize these industrial wastes to a larger extent. Lignite flyash (LFA), which is a by product of thermal power unit called as a waste material can be beneficially utilized for increasing agriculture production (*Lal et al*., 2007). A quantity of 7-10 mt lignite fly ash accumulated annually and only a small quantity of the lignite fly ash is supplied to the cement factories. `The disposal of LFA is done through land fill and such practices consumed more valuable land areas and the ground water gets contaminated due to leaching of elements present in LFA (Manisha Basu *et al*., 2009). Lignite Fly ash, though it is a

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good source of many nutrients, its use remains unexploited for agriculture. Further, the scope of utilization of lignite fly ash in agriculture, which would go a long way in solving the waste management problems faced by Neyveli Lignite Corporation and coal industries. For the purpose of agricultural use, the transport of fly ash to far-away places may cost more. So utilization near the generation source is much beneficial (CARD, 2011).Industrial waste such as press mud or filter cake is a by product of sugar factories reported to be a valuable resource of plant nutrient and may therefore alter the physical, chemical and biological properties of alter the soil (Muhammad and Khattak, 2009). Therefore land application of press mud is being a common farm practice in the sub continent countries of India (Said Ghulam *et al*., 2012).

Intercropping is being looked as an efficient and most economical production system as it not only increases the production per unit area per unit time but also improves resources use efficiency and improved economic status of the farmers. Crop geometry is one of the important factors which has to be maintained optimum level to harvest maximum solar radiation and utilizes the soil resources effectively. (Thavaprakash and Velayutham, 2007). Keeping all this in view, an attempt has been planned to utilize lignite fly ash in effective manner along with press mud or farmyard manure for improving the productivity of crops in Cuddalore district which is considered to be an industrial area where large number of thermal power units are located. Under these circumstances, there is an imperative need to maximize the productivity of maize based cropping system without affecting the fertility of soil. Hence, field experiments were designed to explore the possible effects of low cost, eco-friendly, technique by using cheaply available industrial wastes.

MATERIALS AND METODS

Field experiments were conducted at Annamalai University Experimental Farm, Annamalainagar to evaluate the effects of lignite flyash with press mud and farmyard manure in maize based intercropping system during summer and *kharif,* 2012. The experiments were laid out in split plot design replicated four times with four main and five sub treatments *viz.,* M_1 - FYM + RDF, M_2 – FYM + LFA + RDF, M_3 – PM + LFA + RDF, M_4 - PM+RDF, S_1-sole Maize, S_2- Maize + Sesamum, S_3- Maize + Black gram, S_4- Maize + Sunflower S_5- Maize + Cow pea and four additional treatments *viz*., I_1-sole blackgram, I_2- Sole cowpea, I_3-sole sesame and I_4-sole sunflower were included separately for comparison. The experimental soil is deep fairly drained clay with available N (228 kg ha^{-1}), P_2O_5 (12.83 kg ha^{-1}) K_2O (312.7 kg ha^{-1}) and Organic matter (0.65%). Lignite fly ash, farmyard manure and press mud were applied as per the treatment schedule. Standard agronomic practices were adopted. Observation on plant height, yield attributes and yield were recorded at appropriate stages.

RESULTS AND DISCUSSION

Growth components

Between two seasons, Kharif recorded the highest growth components and grain yield of maize when compared to the summer sown crop. The yield reduction in summer season might be due to the prevalence of high temperature during vegetative, flowering and grain filling stages of the crop. This is in confirmatory with the findings of Shang Wei Nie *et al*. 2012, maize is a warm and fertilizer loving crop, and the high temperature during summer will affect the root development and further yield. The growth and yield of maize was significantly influenced due to the application of lignite fly ash, press mud and intercrops (Sesamum, blackgram, sunflower and cowpea). Lignite fly ash along with press mud showed a positive influence on maize yield. Taller plants of maize was obtained in the integrated application of press mud @ 12.5 t ha^{-1} + LFA @ 5 t ha^{-1} + RDF and it was followed by LFA @ 5 t ha^{-1} with FYM and RDF. This may be due to the presence of macro and micro nutrients in the LFA, which is essential for silicicolous plants like maize and also press mud which is a very good organic fertilizer, soil ameliorating source for sustaining crops (Kumarimanimuthu Veeral 2012, Muhammad Jamil Khan *et al.,* 2012).

Intercropping system of maize + cowpea / blackgram showed a positive influence on maize yield. This may be due to complementary interaction between component crops in the initial stages. Application of agro, industrial solid wastes apart from supplying nutrients for the crops, influences the plant growth physiologically and provides growth regulating substances rectifies and improves microbial properties of the soil. This is the reason for enhancing the DMP and LAI in maize, and it helped to accumulate more photo system and produced highest LAI at flowering. This is online with the findings of Memon *et al*. 2012 and Kumarimanimuthu Veeral, 2012.They stated that industrial wastes improve the soil fertility, physiological activity and finally the yield. Maize incropped with cowpea and blackgram recorded the taller plants due to lesser competitive effect of cowpea and blackgram. It leads to production of more number of functional leaves that owing to increased plant height, LAI and DMP obtained in this system (Ghosh *et al*., 2007 and Moses *et al*., 2010).Tasselling and silking were the critical stages for maize and better light interception during that stage resulted in higher DMP. At all the stages, Maize intercropped with sunflower / sesamum recorded the least of all growth parameters and this may be due to the severe competition offered by sunflower / sesamum to the base crop of maize.

Yield components and yield of maize

The yield and yield components were positively and significantly influenced by lignite flyash application along with press mud. This treatment excelled other treatments, because the integrated waste utilization or conjunctive use of different nutrient sources is an alternative and characterized by reducing the input of chemical fertilizer, but they accumulate and increase the availability of nutrients, and the released nutrients from the mineralization process has a fertilizing effects on the arable crops (Anbul Fatah Soomro *et al*., 2012). When maize is intercropped with cowpea by adding Lignite fly ash along with press mud and RDF exerted least competition and contributed to the nutrient requirement of the base crop through combined application of LFA, press mud and RDF and symbiotic fixation of N by legume crop cowpea. The farmers practice recorded the significantly the least yield attributes *viz*., cob length, cob diameter, number of grain cob^{-1}, and least grain yield. This

Table 1. Plant height at harvest (cm)

Sub treatments	Kharif					Summer				
	Main treatments					Main treatments				
	M_1 FYM + RDF	M_2 – FYM + LFA + RDF	M_3 – PM + LFA + RDF	M_4 – PM + RDF	Mean	M_1 FYM + RDF	M_2 – FYM + LFA + RDF	M_3 – PM + LFA + RDF	M_4 – PM + RDF	Mean
S_1 – Maize alone	120.2	136.7	144.4	129.8	132.77	126.60	143.10	150.80	136.20	139.17
S_2 – Maize + sesamum	125.5	139.6	148.2	131.7	136.25	131.90	146.00	154.60	138.10	142.65
S_3 – Maize + black gram	144.8	158.3	169.1	152.6	156.2	151.20	164.70	175.50	159.00	162.6
S_4 – Maize + sunflower	131.9	145.4	156.4	138.5	143.05	138.30	151.80	162.80	144.90	149.45
S_5 – Maize + cow pea	163.5	177.7	142.3	169.3	175.7	169.90	184.10	198.70	175.70	182.1
Mean	137.18	151.54	162.08	144.38		143.58	157.94	168.48	150.78	

	Main treatments	Sub treatments	Interaction		Main treatments	Sub treatments	Interaction	
			SXM	MXS			SXM	MXS
SE_D	4.2	5.0	3.1	3.0	4.4	5.2	2.8	3.1
CD (P=0.05)	8.4	10.1	6.2	6.1	8.8	10.4	5.6	6.2

FYM @ 12.5 t ha^{-1} + LFA @ 5 t ha^{-1} + RDF
Press mud @ 12.5 t ha^{-1} + LFA @ 5 t ha^{-1} + RDF

Table 2. Cob length (cm)

Sub treatments	Kharif					Summer				
	Main treatments					Main treatments				
	M_1 FYM + RDF	M_2 – FYM + LFA + RDF	M_3 – PM + LFA + RDF	M_4 – PM + RDF	Mean	M_1 FYM + RDF	M_2 – FYM + LFA + RDF	M_3 – PM + LFA + RDF	M_4 – PM + RDF	Mean
S_1 – Maize alone	12.1	13.9	14.7	12.8	13.375	13.2	15.0	15.8	13.9	14.47
S_2 – Maize + sesamum	13.4	15.4	16.6	14.9	15.075	14.6	16.5	17.7	16.0	16.17
S_3 – Maize + black gram	14.6	16.7	17.1	15.6	16.0	15.7	17.8	18.2	16.7	17.1
S_4 – Maize + sunflower	12.6	13.9	14.8	13.0	13.575	13.7	15.0	15.9	14.1	14.67
S_5 – Maize + cow pea	16.9	19.9	22.4	18.8	19.5	17.2	21.0	23.5	19.9	20.4
Mean	13.92	15.96	17.2	15.02		14.86	17.02	18.22	16.12	

	Main treatments	Sub treatments	Interaction		Main treatments	Sub treatments	Interaction	
			SXM	MXS			SXM	MXS
SE_D	0.2	0.3	0.7	0.8	0.3	0.31	0.8	0.8
CD (P=0.05)	0.4	0.7	1.4	1.6	0.6	0.63	1.6	1.6

FYM @ 12.5 t ha^{-1} + LFA @ 5 t ha^{-1} + RDF
Press mud @ 12.5 t ha^{-1} + LFA @ 5 t ha^{-1} + RDF

Table 3. Grain yield (kg ha^{-1})

Sub treatments	Kharif					Summer				
	Main treatments					Main treatments				
	M_1 FYM + RDF	M_2 – FYM + LFA + RDF	M_3 – PM + LFA + RDF	M_4 – PM + RDF	Mean	M_1 FYM + RDF	M_2 – FYM + LFA + RDF	M_3 – PM + LFA + RDF	M_4 – PM + RDF	Mean
S_1 – Maize alone	2460	2840	3118	2648	2767	2770	3150	3428	2958	3077
S_2 – Maize + sesamum	2922	3870	4429	3463	3671	3232	4180	4739	3773	3981
S_3 – Maize + black gram	3971	4761	5030	4454	4554	4281	5071	5340	4764	4864
S_4 – Maize + sunflower	3543	4100	4460	3796	3975	3853	4410	4770	4106	4285
S_5 – Maize + cow pea	4419	5270	5831	4468	5122	4729	5580	6141	5278	5432
Mean	3463	4168	4574	3766		3893	4478	4884	4176	

	Main treatments	Sub treatments	Interaction		Main treatments	Sub treatments	Interaction	
			SXM	MXS			SXM	MXS
SE_D	75.2	101.2	110.1	115.2	80.4	104.5	114.2	118.5
CD (P=0.05)	150.4	202.4	220.2	230.4	160.8	208.1	228.4	226.1

FYM @ 12.5 t ha^{-1} + LFA @ 5 t ha^{-1} + RDF
Press mud @ 12.5 t ha^{-1} + LFA @ 5 t ha^{-1} + RDF

may be due to severe nutrient stress throughout the crop growth. Application of press mud along with lignite fly ash, and RDF to maize + cowpea recorded the highest grain yield, because of the nutrients supplied by LFA and press mud. This was confirmed with the findings of Kumarimanimuthuveeral, 2012 that for sustainable crop production, integrated use of organic and inorganic fertilizer has proved to be highly beneficial. The yield components of maize *viz*., cob length, cob girth and number of grain cob^{-1} and grain yield were increased under maize + cowpea intercropping system. This may be due to complementary effect of cowpea favoured source sink relationship in maize to produce. The yield components as well as grain yield of maize were comparatively more intercropping system than sole maize. The increased grain yield under intercropping system was due to weed suppression by intercrop by the way of covering the land surface. Generally all growth and yield parameters were higher in maize intercropped with legumes than in maize raised in pure stand and intercropped with oil seeds. This may be attributed to the beneficial effects of legumes as associated crops (Sivanesan, 2006). Among the various cropping systems and industrial wastes tested, the maize + cowpea intercropping system with application of press mud and lignite fly ash was found to be superior in reducing the weed competition and increasing the grain yield. Improved crop performance with the addition of lignite fly ash @ 5 t ha^{-1} with press mud and RDF was responsible for higher returns. The returns were also improved with complimentary grain yields of cowpea as intercrop leading to higher yields of maize. Hence this treatment recorded the highest net income and BCR.

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