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Economics of Hybrid Maize Production Using of Lignite and Poultry Manure Based Humin in an Acid Soil of Eastern Dry Zone of Karnataka

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Authors' contributions

This work was carried out in collaboration among all authors. Author Chandrakant designed and conducted the study, performed the statistical analysis and written the manuscript. Author GGK guided during entire research work and corrected manuscript. Author PKB helped in improving the quality of paper with valuable suggestions. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To study the effect of lignite humin (LH) and poultry manure humin (PMH) application on economics of hybrid maize production in an acid soil of eastern dry zone of Karnataka.
Study Design: Randomized complete block design (RCBD) comprising ten treatments and three replications.
Place and Duration of Study: Krishi Vigyana Kendra, Hadonahalli, Bengaluru rural district (Karnataka) during *kharif* 2018.
Methodology: A field experiment was laid out in a randomized complete block design with ten treatments, replicated thrice during *kharif* 2018 at Krishi Vigyana Kendra, Hadonahalli, Bengaluru rural district, Karnataka. The Lignite Humin (LH) and Poultry Manure Humin (PH) were applied at different doses (0, 2.5, 7.5 & 10 t ha^{-1}) in combination with FYM (Farm Yard Manure) applied in such a way that the total quantity of humin and FYM is equivalent to 10 t ha^{-1}.
Results: The results revealed that significant variation was observed on yield and benefit: Cost ratio due to application of Farm Yard Manure (FYM), LH and PMH. Significantly higher maize

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kernel (8070 kg ha^{-1}) and stover yield (9948 kg ha^{-1}) were recorded in treatment T_2 (100% RDF + FYM @ 10 t ha^{-1}) and which was found on par with treatment T_7 (100% RDF + PMH @ 2.5 t ha^{-1} + FYM @ 7.5 t ha^{-1}) and T_3 (100% RDF + LH @ 2.5 t ha^{-1} + FYM @ 7.5 t ha^{-1}) and T_8 (100% RDF + PMH @ 5 t ha^{-1} + FYM @ 5 t ha^{-1}). Wherein, higher B:C ratio of 2.24 was recorded in treatment T_{10} receiving 100% RDF + PMH @ 10 t $ha^{-1}$and it was followed by treatment receiving T_2(2.21) and T_9: 100% RDF + PMH @ 7.5 t ha^{-1} + FYM @ 2.5 t ha^{-1} (2.20). Whereas the least B:C ratio (1.72) was observed in the absolute control treatment where no manures and fertilizers were given.

Conclusion: These results suggest that higher B:C ratio in these treatments might be due to lower cost of cultivation and it increases with increased in dose of lignite and poultry manure based humin.

Keywords: FYM; lignite based humin; poultry manure based humin; soil properties.

1. INTRODUCTION

Organic matter is considered as the “life of soil” due to its importance in maintaining fertility of the soil, the depletion of the same will become a major threat to food security in the years to come. Hence, there is a need to improve the soil fertility in a sustainable manner by utilizing the locally available organic wastes because these wastes contains substantial amount of nutrients which are necessary for the plant growth in addition to maintaining of soil health. It helps in improving soil physical, chemical and biological properties of soil. However, to improve the organic matter content of soils many management techniques have been adopted such as crop rotation, plough techniques, green manuring and application of animal residues, humic acids, humates and other organic wastes [1].

The most active fraction of humus is the humic substances. Hayes et al. [2] described them as a group of naturally occurring, biogenic, heterogeneous organic substances that can generally be characterized as yellow to black coloured high molecular weight material. This group of organic substances can be fractionated in terms of their solubility in acid and alkali into (i) yellowish fulvic acid that is soluble in acid and alkali; (ii) blackish humic acid that is insoluble in acid but soluble in alkali, and (iii) humin that is insoluble both in acid and alkali Stevenson & Cole, [3].

Nowadays use of humic acid and/ fulvic acid is very common in crop production especially horticulture crops as it influences many soil properties (soil application) and helps in mobility and absorption of nutrients in the plant (foliar application). Thus humic acid derived from organic wastes like farm yard manure (FYM), cocopeat, pressmud, coffee pulp, sewage sludge, poultry manure (PM), urban compost etc. which have substantial quantities of humic materials are of great importance in maintaining soil organic matter levels especially in semi-arid tropics of India. However, among the fractions of humic substances, humin fraction which accounts 60-90 per cent of organic manure gets very little attention. It seems to be somewhat inert but it has been described as acting like a sponge, soaking up nutrients. Gary Zimmer [4] reported that the humin may be a humic substance in association with mineral oxides or hydroxides (from the reaction). Alternatively, humin may be coated with hydrocarbons or lipids (fats) that were stripped during the reaction, making them insoluble to aqueous solvents. No research data is available on use of such huge quantity of humin generated after alkali extraction for crop production and their effect on economic study. Hence, a study was initiated to know the effect of application of humin residue on economics of hybrid maize crop in an acid soil in eastern dry zone of Karnataka.

2. MATERIALS AND METHODS

2.1 Extraction of Humic Substances

Two sources of manures such as lignite and Poultry Manure (PM) were used for extraction of humin. Lignite was procured from Neyveli Lignite Corporation of India, located at Neyveli, Tamil Nadu and poultry manure from Poultry Farm, Doddaballapura, Bengaluru rural district. The field scale extraction of humic substances from selected organic manures was carried out by taking 10kg of air dried sample into a 200 L drum to which 100 L 0.1 N NaOH was added, and incubated for 24 hours with periodical stirring with long stick. The dark coloured supernatant containing humic acid and fulvic acid were separated by filtering using muslin cloth. The residue left after extraction is humin Schnitzer and Skinner, [5]. The humin recovered from poultry manure and lignite were weighed and expressed in per cent.

2.2 Characterization of Manures and Humin

The FYM, PM, lignite and humin residues from PM and lignite were characterized for chemical properties viz., pH, EC and OC by Jackson, [6], and nutrient composition viz., total major nutrients (N, P and K), secondary nutrients (Ca, Mg and S), sodium by (Piper, [7] and micronutrients (Zn, Cu, Fe, Mn and B) content following procedures as outlined by Lindsay and Norvell, [8]. They also subjected for water holding capacity (WHC) and bulk density (BD) analysis following standard procedures [7].

2.3 Field Experiment

A field experiment was laid out in a randomized complete block design with ten treatments, replicated thrice during kharif 2018 at Krishi Vigyana Kendra, Hadonahalli, Bengaluru rural district, Karnataka. The Lignite Humin (LH) and Poultry Manure Humin (PH) were applied at different doses (0, 2.5, 7.5 & 10 t ha^{-1}) in combination with FYM (Farm Yard Manure) applied in such a way that the total quantity of humin and FYM is equivalent to 10 t ha^{-1}. The treatment details are as follows.

T_1: Absolute control
T_2: 100% RDF + FYM @ 10 t ha^{-1} (POP)
T_3: 100% RDF + 25% Lignite humin (2.5 t ha^{-1}) + FYM @ 7.5 t ha^{-1}
T_4: 100% RDF + 50% Lignite humin (5 t ha^{-1}) + FYM @ 5 t ha^{-1}
T_5: 100% RDF + 75% Lignite humin (7.5 t ha^{-1}) + FYM @ 2.5 t ha^{-1}
T_6: 100% RDF + 100% Lignite humin (10 t ha^{-1})
T_7: 100% RDF + 25% PM humin (2.5 t ha^{-1}) + FYM @ 7.5 t ha^{-1}
T_8: 100% RDF + 50% PM humin (5 t ha^{-1}) + FYM @ 5 t ha^{-1}
T_9: 100% RDF + 75% PM humin (7.5 t ha^{-1}) + FYM @ 2.5 t ha^{-1}
T_{10}: 100% RDF + 100% PM humin (10 t ha^{-1})

In all the treatments except absolute control, Recommended Dose of Fertilizer (RDF) for maize was applied commonly @ 150:75:40 kg ha^{-1} $N:P_2O_5:K_2O$. The FYM and various combinations of FYM with lignite and poultry manure based humin were applied as per the treatments 15 days before sowing and mixed well with the soil properly. Entire dose of P and K were applied at the time of sowing whereas, N was applied in three splits where 50% at basal, 25% at 30 and 50 days after sowing (DAS). The maize kernel and stover yield of net plot were recorded and expressed in kg per hectare.

The cost of inputs that were prevailing at the time of their use was considered for working out the economics of various treatment combinations. A net return per hectare was calculated by deducting the cost of cultivation from gross income per hectare. Benefit cost ratio was calculated using the following formula.

$$Benefit\ cost\ ratio\ (B{:}C\ ratio) = \frac{Gross\ returns(Rs.)}{Cost\ of\ cultivation(Rs.)}$$

These data's viz., grain yield and stover yield were statistically analysed by adopting standard procedures outlined by Gomez and Gomez [9].

3. RESULTS AND DISCUSSION

Variation was observed on yield and benefit: cost ratio of maize crop production due to different treatment imposition and the results are presented in Table 2&3.

3.1 Characterization of Organic Manures and Humin

The data on the chemical composition and characteristics of organic materials like FYM, poultry manure and lignite before and after alkali extraction are presented in the Table 1. The analysis of the samples revealed that the FYM was slightly acidic (pH 6.04), with 0.77 dS m^{-1} electrical conductivity, 0.47 g m^{-3}, Bulk density, 43.86 per cent water holding capacity and 17.42 per cent organic carbon content. Lignite and poultry manure recorded acidic (4.60) and slightly alkaline (7.83) pH, respectively which after alkali extraction raised to 6.20 and 9.89, respectively. Similarly due to alkali treatments the electrical conductivity was raised from 0.52 and 0.94 to 0.82 and 1.15 dS m^{-1}, respectively in lignite and poultry manure. However, the electrical conductivity is well within the permissible limit (<4.0 dS m^{-1}). Among the sources, poultry manure humin was rich in nutrients compared to lignite based humin which could be supported by the results of Avinash et al. [10]. Total macro nutrients (N, P, K, Ca, Mg and sulphur) and micronurients content were recorded higher in both poultry manure and its humin compared to lignite and its humin. However, the organic carbon content was higher in lignite compared to poultry manure. All these nutrients content were found slightly lower after alkali extraction (Humin) compared to before extraction.

3.2 Kernel and Stover Yield (kg ha^{-1})

Significantly higher maize kernel and stover yield was with T_2: 100% RDF + FYM @ 10 t ha^{-1} (8070 and 9948 kg ha^{-1}) over all other treatments, but was statistically at par with T_7: PMH @ 2.5 t ha^{-1} + FYM @ 7.5 t ha^{-1} (7711 and 9255 kg ha^{-1}), T_3: LH @ 2.5 t ha^{-1} + FYM @ 7.5 t ha^{-1} (7662 and 8877 kg ha^{-1}) and T_8: PMH @ 5 t ha^{-1} + FYM @ 5 t ha^{-1} (7470 and 8844 kg ha^{-1}). Lower kernel yield was recorded in absolute control (3885 and 3907 kg ha^{-1}). Application of inorganic fertilizers in combination with FYM, poultry manure and lignite based humin significantly increased the stover and kernel yield of maize over control. This increase in yield might be attributed to increased growth and yield parameters viz., plant height, number of leaves per plant, cob length, number of rows per cob, number of kernels per row and test weight in maize crop due to different approaches of fertilizer application Ashok and Jayadeva [11]. Though application of humin in combination with FYM did not increase the maize yield significantly over T_2: 100% RDF + FYM @ 10 t ha^{-1} (POP), but found on par with POP when FYM was replaced with humin to the extent of 5.0 t ha^{-1} for PM humin and 2.5 t ha^{-1} for lignite based humin. Further, increased application of PM humin (>5 t ha^{-1}) and lignite based humin (>2.5 t ha^{-1}) significantly decreased kernel and stover yield of maize compared to POP treatment. This suggest that FYM could be replaced to the extent of 5 t ha^{-1} with PM humin or 2.5 t ha^{-1} with lignite based humin without compromising the yield of maize.

Even though higher nutrient content in poultry manure based humin compared to FYM but still recorded lower yield with increased application rate of PM humin, this might be attributed to higher amount of insolubility of nutrients content in humin based sources compared to FYM, because humin is a highly stable formed complex product and their nutrient solubility decreases with increased rate of application compared to humic acid and fulvic acid which is extracted from different organic sources. Similar results were noticed by Theng in 1999 [12], where mobility and solubility of nutrient content in aqueous condition decreases in the order of humic acid>fulvic acid >humin in lignite based humic fractions and they also found that nutrient availability decreases with increased humin content.

Among two sources of humin, application of poultry manure based humin resulted in higher grain and stover yield compared to corresponding doses of lignite humin. This higher yield might be attributed to higher nutrient content in poultry manure compared to lignite based humin (Table 2) Avinash et al. [10].

3.3 Cost Economics of Maize Production

The data on cost economics of maize cultivation as influenced by lignite and poultry manure based humin is presented in Table 3. The higher gross return was recorded in treatment receiving T_2 : 100% RDF + FYM @ 10 t ha^{-1} (Rs.1,50,241) followed by T_7 : PMH @ 2.5 t ha^{-1} + FYM @ 7.5 t ha^{-1} (Rs. 1,43,428), T_3 : LH @ 2.5 t ha^{-1} + FYM @ 7.5 t ha^{-1} (Rs.1,42,372) and T_8 : PMH @ 5 t ha^{-1} + FYM @ 5 t ha^{-1} (Rs. 1,38,889). The least gross return was recorded in T_1: Absolute control plot (Rs.71,887). The higher net return was recorded (Rs. 82,235) in treatment T_2 : 100% RDF + FYM @ 10 t ha^{-1} followed by treatment receiving T_7 : PMH @ 2.5 t ha^{-1} + FYM @ 7.5 t ha^{-1} (Rs.77,672), T_3 : lignite humin @ 2.5 t ha^{-1} + FYM @ 7.5 t ha^{-1} (Rs.76,617) and T_8 : PMH @ 5 t ha^{-1} + FYM @ 5 t ha^{-1} (Rs.75,383). The least net returns was recorded (Rs. 30,050) in T_1: Absolute control plot where no manures and fertilizers were applied.

There no much variation in B:C ratio were observed among the treatments except absolute control. The higher B:C ratio of 2.24 was recorded in treatment receiving T_{10} : PMH @ 10 t ha^{-1} and it was followed by treatment receiving T_2: 100% RDF + FYM @ 10 t ha^{-1} (2.21) and T_9: PMH @ 7.5 t ha^{-1} + FYM @ 2.5 t ha^{-1} (2.20). Whereas the least B:C ratio (1.72) was observed in the treatment which received T_1: Absolute control plot where no manures and fertilizers were given.

Higher gross returns and net returns were recorded in treatment receiving 100% RDF + FYM @ 10 t ha^{-1} fertilizers followed by treatment T_7: PMH @ 2.5 t ha^{-1} + FYM @ 7.5 t ha^{-1}. Whereas, higher B:C ratio recorded in T_{10} receiving PMH @ 10 t ha^{-1} followed by treatment T_2 receiving100% RDF + FYM @ 10 t ha^{-1} and

Table 1. Chemical composition and characteristics of organic manures

Parameters	FYM	Lignite		Poultry manure	
		Before alkali extraction	After alkali extraction (humin)	Before alkali extraction	After alkali extraction (humin)
pH (1:5)	6.04	4.60	6.20	7.83	9.89
EC (ds m^{-1})	0.77	0.52	0.82	0.94	1.15
OC (%)	17.42	56.34	49.41	33.05	31.38
Total N (%)	0.47	0.45	0.42	2.79	2.03
Total P (%)	0.32	0.30	0.25	1.58	1.04
Total K (%)	0.43	0.43	0.39	1.97	1.36
Total Na (%)	0.23	0.07	0.26	0.53	0.82
Total Ca (%)	1.48	1.60	1.30	3.90	2.90
Total Mg (%)	0.73	0.70	0.50	1.80	1.40
Total S (%)	0.21	0.24	0.22	0.52	0.44
Total Fe (mg kg^{-1})	1356.30	985.26	650.06	3750.00	1389.71
Total Mn (mg kg^{-1})	167.24	174.00	73.45	533.80	217.95
Total Cu (mg kg^{-1})	35.45	43.62	23.75	73.60	52.87
Total Zn (mg kg^{-1})	72.32	42.25	41.13	468.00	183.41
Total B (mg kg^{-1})	44.92	38.74	32.68	75.12	49.86
BD (Mg m^{-3})	0.47	0.43	0.61	0.49	0.59
MWHC (%)	43.86	41.66	38.64	46.05	39.82
C:N ratio	37.06	125.26	117.61	11.84	15.45

Table 2. Effect of lignite and poultry manure based humin on kernel and stover yield of maize

Treatments	Yield (kg ha^{-1})	
	Kernel	Stover
T_1 : Absolute control	3885	3907
T_2 : FYM @ 10 t ha^{-1} (POP)	8070	9948
T_3 : 25% Lignite humin (2.5 t ha^{-1}) + FYM @ 7.5 t ha^{-1}	7662	8877
T_4 : 50% Lignite humin (5 t ha^{-1}) + FYM @ 5 t ha^{-1}	7366	8788
T_5 : 75% Lignite humin (7.5 t ha^{-1}) + FYM @ 2.5 t ha^{-1}	7048	8100
T_6 : 100% Lignite humin (10 t ha^{-1})	6825	7906
T_7 : 25% PM humin (2.5 t ha^{-1}) + FYM @ 7.5 t ha^{-1}	7711	9255

Treatments	Yield (kg ha^{-1})	
	Kernel	Stover
T_8 : 50% PM humin (5 t ha^{-1}) + FYM @ 5 t ha^{-1}	7470	8844
T_9 : 75% PM humin (7.5 t ha^{-1}) + FYM @ 2.5 t ha^{-1}	7251	8588
T_{10} : 100% PM humin (10 t ha^{-1})	7111	8077
S.Em. ±	231	386
C.D. at 5%	689	1147

Table 3. Effect of lignite and poultry manure based humin on economics of maize production

Treatments	Cost of cultivation Rs. ha^{-1}	Gross returns	Net returns	B:C ratio
T_1 : Absolute control	41838	71887	30050	1.72
T_2 : FYM @ 10 t ha^{-1} (POP)	68005	150241	82235	2.21
T_3 : 25% Lignite humin (2.5 t ha^{-1}) + FYM @ 7.5 t ha^{-1}	65755	142372	76617	2.17
T_4 : 50% Lignite humin (5 t ha^{-1}) + FYM @ 5 t ha^{-1}	63505	136994	73489	2.16
T_5 : 75% Lignite humin (7.5 t ha^{-1}) + FYM @ 2.5 t ha^{-1}	61255	130917	69661	2.14
T_6 : 100% Lignite humin (10 t ha^{-1})	59005	126820	67815	2.15
T_7 : 25% PM humin (2.5 t ha^{-1}) + FYM @ 7.5 t ha^{-1}	65755	143428	77672	2.18
T_8 : 50% PM humin (5 t ha^{-1}) + FYM @ 5 t ha^{-1}	63505	138889	75383	2.19
T_9 : 75% PM humin (7.5 t ha^{-1}) + FYM @ 2.5 t ha^{-1}	61255	134828	73572	2.20
T_{10} : 100% PM humin (10 t ha^{-1})	59005	132039	73033	2.24

T_9 : PMH @ 7.5 t ha^{-1} + FYM @ 2.5 t ha^{-1}. Higher B:C ratio in these treatments is due to lower cost of cultivation. Irrespective of the doses, higher B:C ratios were observed in the treatments receiving poultry manure based humin compared to lignite based humin and it increases with increased in dose of poultry manure based humin.

4. CONCLUSION

From the present study, looking at the yield and cost benefit ratio, it can be concluded that application of humin residue of poultry manure (upto 100%) and lignite (upto 25%) after alkali extraction of humic and fulvic acids helps in getting higher benefit: Cost ratio of maize crop due to application of lignite and poultry manure based humin compared to control plots.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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