

## Comparative Study of Organic Matter and Humic Acid on N Mineralization in Rice-Mustard Cropping Sequence

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**Abstract** The influence of organic matter vis-a-vis humic acids on soil nitrogen status and its availability and economic impact, during the cultivation of rice (variety MTU 1010) followed by mustard (variety B-9), was studied in the soil of Typic *Fluvaquent* situated in old alluvial soil of West Bengal, India. The status of soil texture, bulk density, oxidizable organic carbon, pH, total nitrogen, available nitrogen and microbial biomass nitrogen were sandy clay loam, 1.34 mg m<sup>-3</sup>, 1.16 g 100g<sup>-1</sup>, 6.34, 0.14 g 100 g<sup>-1</sup>, 231.36 kg ha<sup>-1</sup>, 11.86 µg g<sup>-1</sup> respectively. The C:N ratio of the added

FYM, commercial and FYM extracted humic acid were 32.11, 32.61, 13.53 respectively. Along with recommended dose of fertilizers, basal soil of paddy (N:P<sub>2</sub>O<sub>5</sub>:K<sub>2</sub>O :: 60:30:30) followed by mustard (N:P<sub>2</sub>O<sub>5</sub>:K<sub>2</sub>O :: 80:40:40) was treated with FYM (@ 5.0 and 2.5 t ha<sup>-1</sup>), commercial humic acid (@ 0.5, 0.25 kg ha<sup>-1</sup>) and FYM extracted humic acid (@ 0.5, 0.25 kg ha<sup>-1</sup>) respectively. The experiment was undertaken with three replications with plot size of (3×4)=12 sqm following the randomized block design (RBD). Rhizosphere (0–15 cm) soil - plant samples were collected and analysed for total nitrogen, available nitrogen, microbial biomass nitrogen, plant uptake and their overall effect on economic yield of crops. As panicle initiation and branching stages of paddy and mustard highest content of total nitrogen was recorded which gradually decline towards harvesting stage. FYM extracted humic acid increased N-availability, MBN in soil which signified N-uptake within plants resulted significant yield of paddy. Residual effect of FYM along with additional dose to mustard resulted highest significant yield of plant biomass whereas irrespective of treatments the yield of mustard is similar.

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### Introduction

Nitrogen is an essential component of all amino acids. These amino acids are the building blocks of all proteins including the enzymes. These amino acids

**Table 1.** Physical and chemical properties of the soils of experiment site.

Sl. No.	Parameters	Unit	Field soil
1	Soil type		Typic <i>Fluvaquent</i>
2	Soil texture		Sandy clay loam
	Mechanical analysis		
	Sand	%	34.8
	Silt	%	20.0
	Clay	%	45.2
3	Bulk density	mg m <sup>-3</sup>	1.34
4	Oxidizable organic carbon	g 100 g <sup>-1</sup>	1.16
5	pH	Soil : water=1:2.5	6.34
6	Total nitrogen	g 100 g <sup>-1</sup>	0.14
7	Available nitrogen	kg ha <sup>-1</sup>	231.36
8	Microbial biomass nitrogen	µg g <sup>-1</sup>	11.86

control virtually all biological processes. It is also essential for carbohydrate use within plants. Plants respond quickly to increased nitrogen availability as a result their leaves turn deep green in color. Nitrogen also stimulates plant productivity [1].

Humic acid is the major constituents of humic substances and it is the integral part of soil organic matter and one of the key component of terrestrial ecosystem. It may form an enzymatically active complex that can carry on reactions that usually assigned to the metabolic activity of living organisms [2]. Humic acid fractions have more soil organic carbon than fulvic acid fractions [3], also contains 20 to 50% amino acid nitrogen, 3 to 10% amino sugar nitrogen, small amount of purine and pyrimidine and the rest unidentified. The amount of amino acid differs depending upon the origin of humic substances without only significant relation between amino acid and soil type [4].

Humic acid can be used as a supplement to chemical fertilizers based on the property of bases exchange capacity, complexing ability required in soil [5] and converts into suitable forms for plant assimilation [6]. It also contains many trace elements and various micronutrients in its structure and these are further complex to form chelates [7] used for plant growth and development [8]. Humic acid serves as a catalyst in promoting microbial activity in soil [9] and increases

**Table 2.** Characteristics of FYM, commercial humic acid purchased from market and FYM extracted humic acid.

Sl. No.	Characteristics	FYM	Humic acid extracted from FYM	Commercial humic acid
1	Oxidizable organic carbon (%)	32.56	29.77	43.36
2	Total nitrogen (%)	1.014	2.2	1.29
3	Viscosity (measured by Ubelhode viscometer)		133.1	139.0
4	E <sub>4</sub> /E <sub>6</sub>		3.193	3.41
5	Functional group [12] (meq Ba)		6.803	6.803
6	Ash free carboxylic group [22] (meq)		628.3	415.9

the rate of root adsorption of mineral ions and their penetration into the cells of plant tissues – correlated with biological availability of carbon pool and subsequently influence plant physiology and growth through respiratory activity via the quinone groups [10]. Humic substances also increases root vitality, nutrient uptake and increased chlorophyll synthesis [11]. Application of humic acid with recommended doses of fertilizers (NPK) increases not only the microbial population but also the microbial biomass [12] in soil.

Continuous cultivation of irrigated rice results deterioration of soil health and gradual declination of yield. In an area of intensive cultivation, application of humic acid as nutrient source may also increase the productivity, reducing time of fallow or green manure of cultivation. Application of humic acid in a rice-blackgram cropping system in presence and absence of organic matter increases rice yield by 35%. The residual crop blackgram treated with humic acid proved its destination influence on grain and hauler yield [13].

Addition of organic matter in improving soil fertility is well recognised [14]. However, direct application of humic acid to soil and foliar as a source of nutrition and improving physical, chemical and biological properties of soils has not been studied in details.

**Table 3.** Changes in total N (g kg<sup>-1</sup>) in soil treated with FYM and humic acid in rice-mustard cropping sequence.

Treatments	Crop							
	Rice				Mustard			
	Days after transplanting of rice				Days after sowing of mustard			
	Tillering	Panicle initiation	Flowering	Harvesting	Treatments	Branching	Flowering	Harvesting
T <sub>1</sub>	0.900	0.980	0.867	0.820	T <sub>1</sub> '	1.36	1.24	0.99
T <sub>2</sub>	0.920	1.013	0.900	0.810	T <sub>2</sub> '	1.24	1.12	1.22
T <sub>3</sub>	1.120	1.260	0.840	0.780	T <sub>3</sub> '	1.12	1.24	0.96
T <sub>4</sub>	1.040	1.177	0.880	0.840	T <sub>4</sub> '	1.11	0.99	1.04
SEm (±)	0.1376	0.0496	0.0197	0.0179	SEm (±)	0.0551	0.0854	0.0654
CD (5%)	0.4761	0.1717	0.0682 (ns)	0.0618 (ns)	CD (5%)	0.1906	0.2956 (ns)	0.2263 (ns)
CV %	23.9543	7.7615	3.9185	3.8101	CV%	7.9056	12.8956	10.7622
SEm (±)			0.0391		SEm (±)		0.0310	
CD (5%)			0.1250		CD (5%)		0.1074	

Therefore, it is of practical significance to study the role of organic matter vis-a-vis humic acid on improvement of nutrient status as well as soil health in rice-mustard cropping system.

### Materials and Methods

Two field experiments are conducted in succession at Sub-divisional Adoptive Research Farm, Kandi, Murshidabad, India having longitude of 23.95°N and latitude 88.03°E. The soil type is Typic *Fluvaquent*. Physical and chemical properties of the soil were presented in Table 1.

Humic acids, used as treatment materials in experiments, extracted from FYM by the process of Beraud et al. [15] and GR grade, commercial humic acid having 8% of ash was purchased from open market. The characteristics of FYM and humic acid purchased from market were placed in Table 2.

Rice (variety MTU-1010) was cultivated with recommended doses of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O at 60, 30 and 30 kg ha<sup>-1</sup> in the form of urea, SSP and MOP respectively to raise the rice crop with best management practices during *kharif* season. Fifty percent of the total fertilizer nitrogen was applied as basal and the rest amount was applied in 2 split doses at tillering and flowering stages of rice. The plot size was 12 (3×4) sqm. The experiment was undertaken following the randomized block design (RBD). Each treatment was replicated thrice. Mustard (B-9) was cultivated as relay crop with

recommended dose of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O at 80, 40 and 40 kg ha<sup>-1</sup> in the form of urea, SSP and MOP respectively. The following treatments were adopted in the 1<sup>st</sup> and 2<sup>nd</sup> experiments in succession.

Treatments of the 1<sup>st</sup> experiment with rice

T<sub>1</sub>=Soil + NPK at recommended dose, T<sub>2</sub>=T<sub>1</sub> + FYM at 5 tons ha<sup>-1</sup> at basal, T<sub>3</sub>=T<sub>1</sub> + Commercial humic acid at 0.5 kg ha<sup>-1</sup> at basal, T<sub>4</sub>=T<sub>1</sub> + Humic acid extracted from FYM at 0.5 kg ha<sup>-1</sup> at basal.

Treatments of the 2<sup>nd</sup> experiment with mustard

T<sub>1</sub>'= Soil + NPK at recommended dose, T<sub>2</sub>' = T<sub>1</sub>' + FYM at 2.5 t ha<sup>-1</sup>, T<sub>3</sub>' = T<sub>1</sub>' + Commercial humic acid at 0.25 kg ha<sup>-1</sup> at basal, T<sub>4</sub>' = T<sub>1</sub>' + Humic acid extracted from FYM at 0.25 kg ha<sup>-1</sup> at basal.

Collection and analysis of soil and plant samples

Rhizosphere soil samples (0–15 cm) were collected from each of the respective treatment plot on tillering, panicle initiation, flowering and harvesting stages of rice followed by branching, flowering and harvesting stages of mustard. Total nitrogen (TN) content of soil and plant samples was estimated with modern FOSS Kjeltex method following the procedure of modified Kjeldahl method as described by Jackson [16]. Avail-

**Table 4.** Changes in available N (kg ha<sup>-1</sup>) in soil treated with FYM and humic acid in rice-mustard cropping sequence.

Treatments	Crop							
	Rice				Mustard			
	Days after transplanting of rice				Days after sowing of mustard			
	Tillering	Panicle initiation	Flowering	Harvesting	Treatment	Branching	Flowering	Harvesting
T <sub>1</sub>	188.16	175.62	163.07	100.36	T <sub>1</sub> '	216.10	170.90	150.53
T <sub>2</sub>	225.79	213.25	175.63	125.45	T <sub>2</sub> '	280.98	250.84	150.53
T <sub>3</sub>	188.17	200.70	124.44	87.82	T <sub>3</sub> '	351.24	200.70	175.62
T <sub>4</sub>	275.97	250.90	225.79	112.91	T <sub>4</sub> '	316.10	250.87	190.69
SEm (±)	4.1643	7.9574	4.5035	2.9522	SEm (±)	2.1841	0.6771	4.5072
CD (5%)	14.4083	27.5319	15.5818	10.2146	CD (5%)	7.5567	2.3427	15.5944
CV %	3.2857	6.5594	4.5290	4.7954	CV%	1.2995	0.5372	4.6791
SEm (±)		9.4670			SEm (±)		18.7222	
CD (5%)		30.2819			CD (5%)		64.7774	

able nitrogen of soil was determined by alkaline potassium permanganate method [17]. The microbial biomass nitrogen of the organic matter and humic acid treated soil samples were estimated by chloroform fumigated direct extraction (CFDE) protocol as established by Joergensen [18].

#### Statistical analysis

Data of the experiments were analyzed statistically for analysis of variance as well as critical difference were calculated at 5% level of significance to test the significance of means for the treatment difference following the procedure as described by Jaggi [19] (SEm = Standard error of mean, CD = Critical difference, CV + Coefficient of variation).

#### Results and Discussion

Effect of FYM at 5 and 2.5 t ha<sup>-1</sup>, commercial and extracted humic acid at 0.5 and 0.25 kg ha<sup>-1</sup> on paddy followed by mustard respectively on the content of total nitrogen in soil were tabulated in Table 3. Commercial humic acid (CHA) with lowest C/N ratio (Table 2) act as readymade source of energy nitrogen to microbial community followed by extracted humic acid (EHA) (33:1). Aerobic bacteria use these as food source for microbial proliferation as compared to other microbial community [20] in soil. The proliferated bacteria had utilised applied humic acids (HAs) resulting

non-significant influence on total nitrogen at tillering stage of rice in soil. After utilizing the urea (inorganic nitrogen source) by the plant and microorganisms applied at basal there might be a serious cry for nitrogen generated within microbial community [21]. It accelerated the rate of microbial degradation of FYM [22] as well as activities of free living N fixing bacteria to fix atmospheric nitrogen [21]. Both the activity was going on simultaneously resulting in significant increase in the content of total nitrogen in soil at panicle initiation (PI) stage. Highest increase at PI stage was recorded with CHA (28.6%) followed by EHA (20.1%) and FYM (3.4%) respectively. Due to higher microbial activity the organic N present in soil is mineralized and utilized by plant [23] showing a declining trend of TN towards harvesting stage [24]. Both flowering and harvesting stage of paddy non-significant influence was recorded in the content of TN over that of control in soil.

During *rabi* season, same field was cultivated with mustard having treatments of FYM, CHA and EHA at 2.5 t, 0.25 and 0.25 kg ha<sup>-1</sup> respectively. Due to residual effect, contents of TN were increased in all mustard plots at branching stage EHA treated plots showed highest declining rate (18.4%) of TN followed by CHA (17.6%) as compared to control in soil. The rate of this declination was narrower towards flowering stage. At harvesting stage due to higher microbial activity on FYM resulted highest increase in the content of TN (23.2%) followed by EHA (5.0%) over that of control in soil [15].

**Table 5.** Changes in microbial biomass nitrogen ( $\mu\text{g g}^{-1}$ ) in soil treated with FYM and humic acid in rice-mustard cropping sequence.

Treatments	Crop							
	Paddy				Mustard			
	Stages after transplanting of rice				Days after sowing of mustard			
	Tillering	Panicle initiation	Flowering	Harvesting	Treatments	Branching	Flowering	Harvesting
T <sub>1</sub>	10.41	14.92	18.97	15.60	T <sub>1</sub> '	16.02	18.70	15.03
T <sub>2</sub>	15.10	16.95	22.15	19.38	T <sub>2</sub> '	21.96	25.00	20.96
T <sub>3</sub>	14.29	26.22	22.95	16.09	T <sub>3</sub> '	17.60	22.43	20.53
T <sub>4</sub>	15.55	26.25	21.81	21.05	T <sub>4</sub> '	32.44	38.58	33.69
SEm ( $\pm$ )	1.3084	2.2187	1.2802	1.5184	SEm ( $\pm$ )	3.3223	0.4715	2.8367
CD (5%)	4.5270(ns)	7.6765	4.42934(ns)	5.2536(ns)	CD (5%)	11.4951	1.6313	9.8147
CV %	16.3775	18.2257	10.3277	14.5866	CV%	26.1506	3.1196	21.7860
SEm ( $\pm$ )		1.3802			SEm ( $\pm$ )		0.6596	
CD (5%)		4.4150			CD (5%)		2.2821	

Table 4 represents changes in available N in soil cropped with paddy followed by mustard with the treatments of FYM, CHA and EHA. The changes in the concentration of available nitrogen truly depends on the changes in TN and other physico-chemical and biological factors [25]. Basal application of EHA and urea jointly increased the available nitrogen towards highest pick (46.7%) followed by FYM (20.0%) as compared to control in soil at tillering stage. Microbial mineralization was mainly responsible for raising amount of available nitrogen, which also affected the content of TN (Table 3) in soil. Along with the cultivation period, available nitrogen tended to decrease with increase in the age of crop. Judicious use of EHA by the microorganisms even by the plant roots [26] referred highest content at both PI (42.9%) and flowering (38.5%) stages followed by FYM 21.4% and 7.7% respectively as compared to control in soil. Added FYM with higher C/N ratio than CHA and EHA, reflected the slower rate of microbial mineralization [27]. During harvesting stage plant did not uplift N but microbial mineralization continued to reach desired C/N ratio which resulted highest amount of available N (25.0%) in FYM treated plot in comparison to control in soil. CHA has low C/N ratio but the percent of N in that was very meagre and rapidly used by the microorganisms as well as plant roots. This might be the reason of decreasing rate of available nitrogen at flowering (23.7%) and harvesting (12.5%) stage of paddy as compared to that of control. In this paddy – mustard cropping pattern mustard have a positive

effect on residual available nitrogen present in soil [28]. Along with this residual effect, basal application of recommended chemical fertilizers raised the content of available nitrogen at control (Table 4). FYM, CHA and EHA acted as addendum on that and reflected significant increase in available nitrogen at branching. CHA in mustard resulted highest significant increase of 62.5% followed by EHA (46.3%) and FYM (30.0%) over control in soil. Mustard cultivation showed similar pattern in the content of available nitrogen as that of paddy (Table 4).

Microbial biomass nitrogen (MBN) is the microbial body protein and amino acids, were build during the microbial growth and utilization of substrates N by the microorganisms for their body build up [29]. After death, this body protein (organic N) was mineralised and inorganic N was released – absorbed by the plant roots [27]. Changes in the content of MBN also reflected the change in the content of available nitrogen in soil and their uses [30]. Table 5 represented this variation in the content of MBN at all stages of paddy cultivation. No definite trend was followed here. Humic acid and FYM were the source of organic N used by the microbes after full utilization of inorganic N [7] supplied at basal. Application of FYM at paddy resulted 2<sup>nd</sup> highest increase in MBN at tailoring (45.1%) and harvesting (24.2%) stage over control in soil. This might be due to early rapid utilization of inorganic N present in FYM for microbial body and further organic N mineralization by microbes [29].

**Table 6.** Changes in N content, dry matter yield and N-uptake at different growth stages of rice grown in soil treated with FYM vis-à-vis humic acid in a rice-mustard cropping sequence.

Treat- ments	Panicle initiation			Flowering			Harvesting (2011-12) Rice						
	N%	Dry matter	Uptake	N%	Dry matter	Uptake	Straw		Grain		N%	Dry matter	Uptake
		(kg ha <sup>-1</sup> )	(kg ha <sup>-1</sup> )		(kg ha <sup>-1</sup> )	(kg ha <sup>-1</sup> )	(kg ha <sup>-1</sup> )	N%	(kg ha <sup>-1</sup> )	(kg ha <sup>-1</sup> )		(kg ha <sup>-1</sup> )	(kg ha <sup>-1</sup> )
T <sub>1</sub>	1.87	216.87	4.06	1.26	445.78	5.62	0.72	4612.50	33.21	1.61	3123.00	50.30	
T <sub>2</sub>	2.06	238.84	4.92	1.50	470.07	7.05	0.90	4923.00	44.33	1.94	3240.00	62.81	
T <sub>3</sub>	2.01	249.15	5.01	1.62	511.80	8.29	0.73	5251.50	38.35	2.26	3636.00	82.18	
T <sub>4</sub>	2.08	267.22	5.56	1.74	528.35	9.19	0.84	5503.50	46.24	2.35	3672.00	86.30	
SEm(±)	0.0152	0.7432	0.0509	0.0850	0.3261	0.4240	0.0205	31.1435	1.3175	0.0712	19.0693	2.3711	
CD (5%)	0.0525	2.5716	0.1760	0.2942	1.1284	1.4671	0.0711	107.7544	4.5584	0.2465	65.9786	8.2038	
CV%	1.3117	0.5297	1.8039	9.6262	0.1155	9.7427	4.4627	1.0634	5.6298	6.0485	0.9664	5.8336	

The amount of MBN present in soil was also depended on MBC and both of them always keep a stable ratio in soil [30]. Cultivation of mustard with earlier stated treatments resulted similar trend in the content of MBN. At branching stage, use of EHA significantly established more than one fold increase in MBN followed by FYM (37.1%) and CHA (9.9%) over control in soil. Over the cultivation period EHA resulted highest increasing rate in the content of MBN (169.6%) followed by FYM and CHA in comparison to control in soil. This might be due to the residual effect of paddy on mustard [28] and microbial use of applied inorganic N in the form of urea.

The average N percent in plant dry weight and uptake by rice and mustard at different stages were presented in Tables 6 and 7. During the growth pe-

riod the percent of plant N gradually declined from PI to harvesting stage whereas at harvesting, the combined N percentage of grain and straw established highest position over the growth period. Positive increment during the growth period implied increase in dry weight towards harvesting stage. Uptake is the calculated figure of percent nutrient and average dry weight. Therefore, changes in nutrient percent and dry weight over the growth period affects nutrient uptake.

Over the cultivation period, application of EHA resulted highest increase in uptake of N by grain at harvesting stage (71.6%) followed by flowering (63.7%) stage. This might be due to movable characteristics of N within plant [1]. Highest uptake of N in EHA treated system was followed by CHA and FYM

**Table 7.** Changes in N content, dry matter yield and N-uptake at different growth stages of mustard grown in soil treated with FYM vis-à-vis humic acid in a rice-mustard cropping sequence.

Treat- ments	Branching			Flowering			Mustard (2011-12)						
	N%	Dry matter	Uptake	N%	Dry matter	Uptake	Stover		Seed		N%	Dry matter	Uptake
		(kg ha <sup>-1</sup> )	(kg ha <sup>-1</sup> )		(kg ha <sup>-1</sup> )	(kg ha <sup>-1</sup> )	(kg ha <sup>-1</sup> )	N%	(kg ha <sup>-1</sup> )	(kg ha <sup>-1</sup> )		(kg ha <sup>-1</sup> )	(kg ha <sup>-1</sup> )
T <sub>1</sub>	1.06	498.00	5.28	1.36	996.00	13.54	0.37	3036.56	11.22	2.11	915.08	19.3	
T <sub>2</sub>	1.00	522.90	5.24	1.61	1643.40	26.49	0.37	3802.23	14.11	2.35	1538.82	36.1	
T <sub>3</sub>	1.07	510.45	5.46	1.36	1776.10	24.17	0.47	2849.81	13.24	2.11	892.67	18.8	
T <sub>4</sub>	1.21	547.80	6.63	1.61	1444.20	23.27	0.50	3036.56	15.19	2.35	1568.70	36.8	
SEm(±)	0.0314	7.8102	0.2298	0.0720	10.3372	1.0348	0.0359	35.2936	1.2100	0.0531	14.4328	0.8027	
CD (5%)	0.1088	27.0229	0.7951	0.2492	35.7662	3.5803	0.1243	122.1135	4.1865	0.1837	49.9365	2.7772	
CV%	5.0200	2.6026	7.0406	8.4018	1.2222	8.1965	14.6001	1.9216	15.5928	4.1260	2.0343	5.0024	

**Table 8.** Yield of paddy and mustard grown under different treatment combinations.

Treat-ments	Paddy yield (t ha <sup>-1</sup> )		Treat-ments	Mustard yield (q ha <sup>-1</sup> )	
	Grain	Straw		Stover	Seed
T <sub>1</sub>	3.470	5.125	T <sub>1</sub> '	35.83	10.00
T <sub>2</sub>	3.600	5.470	T <sub>2</sub> '	44.17	10.41
T <sub>3</sub>	4.040	5.835	T <sub>3</sub> '	29.16	10.16
T <sub>4</sub>	4.080	6.115	T <sub>4</sub> '	40.83	10.50
SEm (±)	0.0752	0.0978	SEm (±)	2.097	0.323
CD (5%)	0.2602	0.3384	CD (5%)	7.257	1.1182(ns)
CV%	3.4301	3.0052	CV%	9.688	5.452

respectively at different growth stages of paddy. This result implied the power of microbial mineralization for nutrient availability [27] in soil. Basal application may bring some close contact between humic acid and plant root which enabled roots to intake fractions of humic acid resulted increase in metabolic activity within plant body. Secretion of metabolically created products through root exudation, resulted increase in N uptake within plant body in exchange reaction [31] resulted highest increase in dry weight in plant, nutrient percentage in grain and all along uptake of nitrogen.

In Table 7, application of the same treatments (variable dose) results increase in N percent, dry weight and nutrient uptake with in plant body. With the same reason highest uptake was recorded in seeds of harvesting stage (90.9%) by EHA, followed by FYM (87.2%) as compared to that of control in plant. Mustard cultivation was followed by paddy and so the residual effect of FYM, applied at *kharif* season along with fresh application at basal of mustard resulted highest increase in N percent and N uptake (95.6%) at flowering stage and 2<sup>nd</sup> highest in stover (25.8%) and seed (87.2%) of harvesting stage as compared to control.

Variation in grain and straw yield of paddy along with stover and seed yield of mustard was tabulated in Table 8. Highest increase in grain (17.58%) and straw (19.32%) yield was recorded with EHA followed by CHA – 16.43% and 13.85% respectively. In mustard highest production of stover (23.28%) and seed (5.0%) was observed with application of FYM and EHA respectively as compared to that of control in

plant. This result in mustard might be due to residual effect of paddy [28].

## Conclusion

Application of EHA at basal collectively with recommended doses of fertilizers increase N – availability, content of MBN in soil which signifies N–uptake within plants resulted significant grain yield of paddy. Residual effect of FYM along with additional dose to mustard resulted highest significant yield of plant biomass whereas irrespective of treatments the quantitative yield of mustard is similar.

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