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Effects of humic acid and macronutrients on fodder maize and fodder cowpea intercropping

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Abstract
A field experiment was conducted during summer (March-May) season of 2021 at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Killikulam to investigate the effects of different nitrogen fertilization rates and humic acid on the fodder yield and quality of maize (African tall) and cowpea (Co 9) intercropping. The experiment was laid out in a randomized block design with 12 treatment combinations, replicated thrice. The experimental results revealed that the basal application of 20 kg ha^{-1} humic acid along with enriched farmyard manure applied with 125% recommended dose of fertilizers (RDF) and foliar application @ 1% Urea on 25 and 45 DAS recorded the maximum green fodder and dry fodder yield of maize (35.14 t ha^{-1}, 5.27 t ha^{-1}) and cowpea (18.51 t ha^{-1}, 2.77 t ha^{-1}) at harvest. The minimum yield was obtained in the absolute control plot. It was found that there is an increase of 66.8% and 56.9% of maize and cowpea green fodder yield respectively over the untreated plot. The maximum crude protein of 11.85% (T_8), crude fibre of 32.22% (T_3), ether extract of 2.65% (T_8) and ash of 12.48% (T_8) from maize and maximum crude protein of 22.42% (T_8), crude fibre of 30.57% (T_{12}), ether extract of 4.5% (T_8) and ash of 22.76% (T_8) from cowpea were obtained from the experimental study. It was concluded that increasing the nitrogen fertilization rate and the humic acid enhanced the green fodder yield, dry fodder yield and improved the quality parameters of both fodder maize and cowpea grown under intercropping.

Keywords: Humic acid, green fodder, dry fodder, quality, intercropping, maize, cowpea

1. Introduction
India holds about 17% of the world's total livestock population which are adapted to different agroclimatic conditions. Livestock farming becomes the most feasible economic livelihood by providing bulk cash income. About 2/3rd of the total cost for livestock management is incurred for feed. Current national deficit accounts for nearly 35.6% in case of green fodder, 10.95% of dry crop residues and 44% of concentrate feed ingredients (Ghosh *et al.*, 2016) [10]. Seasonal and regional deficiencies are more important because it is difficult to transport available fodder over long distances. Higher productivity of livestock can be achieved by providing quality feed, required nutrition and proper health care. To enhance the availability of fodder crops either by increasing productivity (Kumar *et al.*, 2012) [16] or maximizing total production by intensive cultivation technologies like multiple cropping, intercropping, and relay cropping (Kumar *et al.*, 2010) [15] or by providing good quality nutritive fodder (Singh *et al.*, 2010) [21] is need of the hour. The cultivated area of forage crops can be increased to maximize production but the demand for agricultural land for food and cash crops is also increasing. Thus, increasing feed availability and reducing the economic cost resulted in higher profit margins for the farming community (Kumar *et al.*, 2017) [14].

Integration of cereal fodder with legumes increased land-use productivity and increased the profit in fodder production. The altered crop spacings paved way for the different intercropping patterns which resulted in higher production (Kumar and Narmadha 2018) [13]. Maize is a versatile crop highly used for grain and fodder production and has wider adaptability in different agroclimatic conditions. It requires good nutrition management and is highly suitable for fodder production because of its quicker growth, succulent nature, higher palatability, and good quality without any antinutritional factors. Forage maize responds to plant densities significantly influencing total dry matter and quality parameters. Higher plant densities affect the number of leaves per plant and stem percentage but have no significant effect on plant height and leaf percentage (Carpici *et al.*, 2010) [5]. Fodder cowpea is a short-duration crop suitable for intercropping with maize because of its rapid growth rate, palatability, higher yield and protein content. Legumes fix atmospheric nitrogen through their root nodules by a bacterium called *Rhizobium leguminasorum* (Acikgoz *et al.*, 2009) [1] that increased the nutrient availability in the soil which not only increased the vegetative growth of their own but also their intercrop. Intercropping increased efficiency and maximized the allocation of resources like space, light and nutrients (Alla, 2014) [2] and also enhanced the crop quality and yield (Amin, 2011) [13].

The addition of organic substances decreased the temperature and enhanced the conservation of moisture in the soil and thereby increased the yield and quality of crop production. Among various applications, humic acid incorporation seems to be one of the feasible options. Levinsky (2008) reported the beneficial role of humates on plant growth, yield, quality and the uptake of nutrients and suggested that 1kg of humic acid can be used as a substitute for 1 ton of farmyard manure.

2. Materials and Methods

2.1. Experimental site and treatment details

A field experiment was conducted at Agricultural College and Research Institute, Killikulam during summer season (March – May, 2021). The research area was located at 8^0 46' N latitude and 77^0 42' E longitude. The analysis of soil samples collected from the experimental field showed a pH of 7.3 with electrical conductivity of 0.08 dSm^{-1}. The availability of N, P and K was low (202 kg ha^{-1}), medium (14 kg ha^{-1}) and medium (240 kg ha^{-1}) respectively and the organic carbon content was 0.458%. The experiment was laid out in a randomized block design replicated thrice with two crops *viz*., fodder maize (African tall) and fodder cowpea (Co9) intercropped at 2:2 paired row system at a spacing of 90/45 x 10 cm. The treatment details were T_1 – 100% RDF + Foliar application of 1.0% MAP + 0.5% $CaCl_2$; T_2 - 100% RDF + Enriched FYM + Foliar application of 1.0% Urea + 0.5% $CaCl_2$; T_3 - 75% RDF + Enriched FYM + 10 kg ha^{-1} HA + Foliar application of 1.0% Urea + 0.5% $CaCl_2$; T_4 - 100% RDF + Enriched FYM + 10 kg ha^{-1}HA + Foliar application of 1.0% Urea + 0.5% $CaCl_2$; T_5 - 125% RDF + Enriched FYM + 10 kg ha^{-1} HA + Foliar application of 1.0% Urea + 0.5% $CaCl_2$; T_6 - 75% RDF + Enriched FYM + 20 kg ha^{-1} HA + Foliar application of 1.0% Urea + 0.5% $CaCl_2$; T_7 - 100% RDF + Enriched FYM + 20 kg ha^{-1} HA + Foliar application of 1.0% Urea + 0.5% $CaCl_2$; T_8 - 125% RDF + Enriched FYM + 20 kg ha^{-1} HA + Foliar application of 1.0% Urea + 0.5% $CaCl_2$; T_9 - 75% RDF; T_{10} - 100% RDF; T_{11}- 125% RDF; T_{12}- absolute control. Humic acid was applied before sowing of seeds along with enriched farmyard manure (750 kg ha^{-1}). The different doses of recommended fertilizer *viz*., 60:40:20 kg NPK ha^{-1} was applied as per treatment schedule. The nitrogen fertilizer applied at two split doses *viz*., basal and at 30DAS. Maize and cowpea were harvested at 55 DAS and 65 DAS respectively at the time of 50% flowering stage. The plant samples were collected and dried and quality parameters such as ether extractable fat, crude protein, crude fiber, dry matter content and ash content of the plant were determined according to the standard methods and procedure recommended by AOAC (Cunniff, 2005).

3. Results and discussions

3.1. Green fodder and dry fodder yield

Green fodder was significantly influenced by various treatments imposed (Table 1). Pooled data indicated that the maximum green fodder yield of maize and cowpea intercropping was obtained by application of 20 kg ha^{-1} HA along with 125% RDF and foliar application of 1% Urea + 0.5% CaCl2 (T_8) that yielded about 35.14 t ha^{-1} and 18.51 t ha^{-1} respectively. The production and productivity of green fodder yield increased in the paired row intercropping system which could be due to the increased plant density and complementary effect of cereal + legume intercropping. Increasing the nitrogen fertilizer application rate also increased the green fodder yield (Shahid 2012) [20]. It was found that humic acid application had a positive influence on green fodder yield which can be enhanced by increasing the humic acid application (Daur and Bakhashwain 2013) [8]. The maximum and minimum green fodder yield of maize was found to be 35.14 t ha^{-1} (T_8) and 21.07 t ha^{-1} (T_{12}) which was 66.8% higher than the control plot (T_{12}). Cowpea green fodder yield was found to be increased by 56.9% over the control plot (T_{12}). The dry matter yield (5.27 t ha^{-1} and 2.77 t ha^{-1} respectively) of fodder maize (T_8) and fodder cowpea (T_8) were found to increase with increasing rate of humic acid @ 20 kg ha^{-1} applied along with an increased rate of fertilizers dose.

3.2. Quality parameters

3.2.1. Crude protein content

Application of humic acid and varied nutrients significantly influenced the fodder quality of both maize and cowpea (Table 4). The maximum crude protein content of fodder maize and fodder cowpea was obtained in T_8 (11.85%, 22.42%) followed by T_7 (11.06%, 21.32%) respectively. This improved quality of the fodder by humic acid application was possibly due to the legume intercropping which helped to fix the atmospheric nitrogen through root nodules thereby increasing the availability of soil nitrogen (Eskandari and Ghanbari 2009; Prasanthi and Venkateswaralu 2014) [9, 19]. Soil application of humic acid increased the nutrient use efficiency of soil nitrogen thereby increased the nitrogen content of the crop which could have simultaneously increased crude protein content (Morard *et al.*, 2010) [18]. Different nitrogen fertilizer application rates had a significant effect on dry matter yield and also crude protein content. Paired row system of maize + cowpea (2: 2) increased the plant density which also increased the crude protein yield (Jiwang *et al.*, 2005) [12]. The humic acid application also increased the dry matter yield and nutrition composition of fodder that was found to have produced a significant influence on the crude protein yield when compared with conventional fertilizer application (100%RDF). The maximum total crude protein yield was obtained in fodder maize in the treatment T_8 (624.61 kg ha^{-1}) (Table 2). which was higher over the 100% RDF application T_{10} (346.53 kg ha^{-1}). In cowpea, the total protein yield of 622.49 kg ha^{-1} was found in T_8 which was higher over the 100% RDF application T_{10} (445.92 kg ha^{-1}).

3.2.2. Crude fibre content

Crude fibre content was found to be significantly influenced by humic acid and fertilization (Table 4). Results revealed that higher crude fibre content of maize was present in T_3 (32.2%) and maximum fibre yield was found in T_4 (1491.6 kg ha^{-1}) (Table 2). which was significantly higher than that of all other treatments. The minimum crude fibre content and yield were obtained in T_{10} (18.05%) and T_{12} (638.4 kg ha^{-1}). The given data depicted that the application of either farmyard manure or combined effects of humic acid along with enriched compost significantly increased the fibrous content of fodder crop than that of conventional application (100%

RDF) alone. It was also found that increasing nitrogen fertilizer application decreased the fibre content while humic acid application increased the fibre content in cereals. In case of fodder cowpea, the maximum fibre content was found in T_{12} (30.57%) followed by T_9 (29.06%) and the maximum fibre yield was obtained in T_4 (657.7 kg ha^{-1}). This summarized that the low nitrogen content of the crop increased the fibre content and humic acid addition decreased the fibre content compared to conventional application. All the fibre compositions were not digestible by ruminants and require higher energy for their conversion. The crude fibre content increased with increasing duration of the crop due to higher accumulation of hemicellulose, cellulose, lignin, silica etc., in the stem portion (Zhang *et al.*, 2007) [22]. Another researcher reported that higher nitrogen content is essential for higher protein synthesis and lower soluble carbohydrates which directly decreased the crude fibre content of the fodder, which increased the palatability and digestibility of the fodder (Mahdi *et al.*, 2012) [17].

3.2.3. Crude fat content/ Ether extract
Crude fat was found increased with the increasing rate of nitrogen fertilizer application and humic acid application (Table 4). Treatment plots applied with 125% RDF along with 20 kg ha^{-1} HA produced the higher crude fat percentage T_8 (2.65%) followed by T_7 (2.40%) in fodder maize. The plots that received 125% RDF along with 10 kg ha^{-1} HA in cowpea have shown the higher ether extract content T_8 (4.45%) followed by T7 (4.20%). Crude fat was also influenced by the harvesting stages of the crop as it gets decreased with maturity (Ayub *et al.*, 2001) [4]. Maximum crude fat content of maize and cowpea respectively was obtained in T_8 (2.65%, 4.45%) and minimum crude fat content in T_{12} (1.69%, 3.03%) at harvest stage.

3.2.4. Total ash content
In the case of fodder maize, the total ash content was found to be significantly higher in T_8 (12.48%) followed by T_7 (11.36%) (Table 4). With respect to fodder cowpea, T_8 (21.89%) recorded higher ash content followed by T_7 (20.82%). The results showed that the application of humic acid increased the ash content in comparison to conventional fertilizer application. In both the crops, ash content was found to be high in untreated plots. The ash content of fodder gets decreased as the crop matured due to the dilution of minerals which increased the dry matter digestibility (Dahmardeh *et al.*, 2009) [7].

3.2.5. Dry matter/ Moisture content
Higher moisture content was found in maize (34.77%) and cowpea (9.22%) in the treatment T_8 (Table 4). The trend that was found is that increasing nitrogen application rate increased the dry matter content. It was also found that increasing the rate of humic acid application also increased the dry matter content and was also influenced by the harvesting stages (Hsu *et al.*, 1987) [11]. The maximum and minimum dry matter content of maize was found in treatments T_8 (34.77%) and T_{12} (26.9%) and in cowpea, it was found in treatments T_8 (9.2%) and T_{12} (7.83%) respectively.

3.3. Gross returns, net returns and B: C ratio
The data relating to gross returns and net returns of maize and cowpea intercropping are presented in Table 3. The higher gross return was recorded from the treatment T_8 (Rs. 72160.0) which was followed by T_7 (Rs. 68530.0). The maximum net return was obtained from treatment T_8 (Rs. 44803.5) which was significantly higher than all other treatments and the minimum net returns was obtained in control treatment T_{12} (Rs. 19560.0). The benefit-cost ratio was found higher (1.83) in the treatment received with 125% recommended dose of fertilizer (T_{11}) followed by treatments T_{10} (1.75).

4. Conclusion
Humic acid application along with the recommended dose of fertilizer and enriched compost influenced the yield and quality of fodder maize and cowpea grown in paired row system of intercropping. Based on the current research findings it is recommended that soil application of humic acid @ 20 kg ha^{-1} along with 125% RDF and foliar application of 1.0% Urea + 0.5% $CaCl_2$ at 25 and 45 DAS (T_8) increased the green fodder yield of maize and cowpea by 66.8% and 56.9%. Crude protein yield of 624.6 kg ha^{-1} and 622.5 kg ha^{-1} in maize and cowpea respectively was recorded in the same treatment. The maximum gross returns (Rs.72160.0) and net returns (Rs. 44803.5) was also obtained from this treatment, however, the treatment, T_{11} (125% RDF) recorded the higher cost benefit ratio (1: 1.83) over the other treatments.

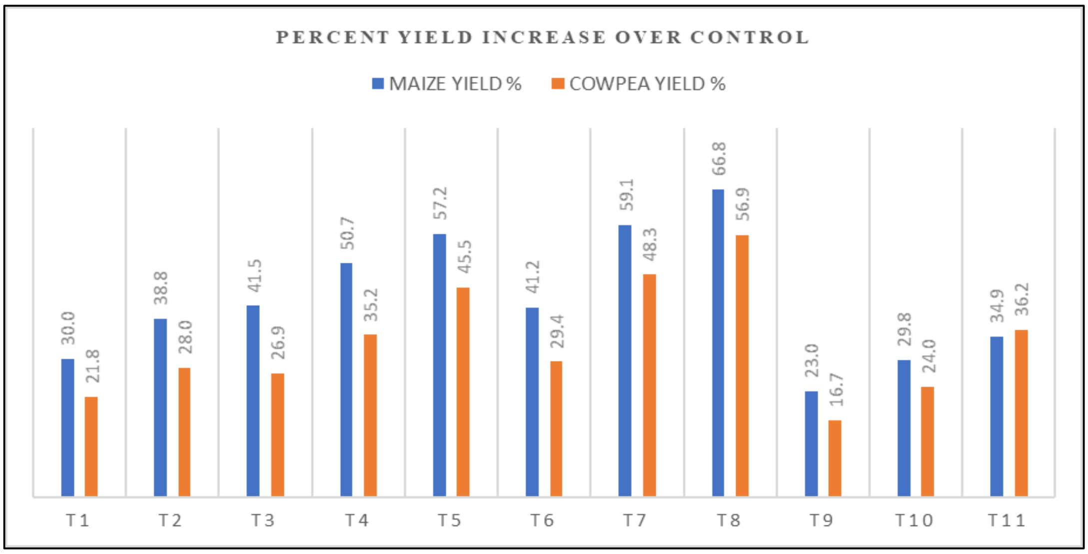

Fig 1: Effect of different rates of humic acid and nutrients on the yield of Fodder Maize and Fodder Cowpea over Control plot (T_{12})

Table 1: Effect of different rates of humic acid and nutrients on green fodder and dry matter yield of maize + cowpea intercropping

Treatments	Maize			Cowpea		
	Dry fodder yield (kg/ha)	Green fodder yield (t/ha)	Yield increases over control (%)	Dry fodder yield (kg/ha)	Green fodder yield (t/ha)	Yield increase over control (%)
T1	4108.5	27.39	30.0	2155.5	14.37	21.8
T2	4387.5	29.25	38.8	2265	15.1	28.0
T3	4471.5	29.81	41.5	2245.5	14.97	26.9
T4	4762.5	31.75	50.7	2392.5	15.95	35.2
T5	4969.5	33.13	57.2	2575.5	17.17	45.5
T6	4462.5	29.75	41.2	2290.5	15.27	29.4
T7	5029.5	33.53	59.1	2625.0	17.5	48.3
T8	5271	35.14	66.8	2776.5	18.51	56.9
T9	3888	25.92	23.0	2065.5	13.77	16.7
T10	4101	27.34	29.8	2194.5	14.63	24.0
T11	4263	28.42	34.9	2410.5	16.07	36.2
T12	3160.5	21.07	0.0	1770	11.8	0.0

Table 2: Effect of different rates of humic acid and nutrients on crude protein, fibre and fat yield of maize + cowpea intercropping

	Crude protein yield (kg/ha)		Crude fibre yield (kg/ha)		Crude fat yield (kg/ha)	
Treatments	Maize	Cowpea	Maize	Cowpea	Maize	Cowpea
T1	349.22	443.39	1189.8	620.1	92.0	77.0
T2	390.49	466.14	1258.3	617.0	99.2	86.3
T3	415.85	469.98	1440.7	638.2	85.0	90.9
T4	495.30	508.17	1491.1	657.7	95.7	99.0
T5	556.09	564.55	1449.6	638.5	108.3	110.7
T6	472.13	475.28	1346.3	597.6	91.9	94.1
T7	556.26	559.65	1421.8	629.5	120.7	110.3
T8	624.61	622.49	1263.5	611.7	139.7	123.6
T9	321.93	409.38	750.0	599.0	75.0	72.3
T10	346.53	445.92	740.2	618.4	87.8	81.4
T11	384.10	503.31	730.7	654.2	97.2	92.8
T12	249.36	331.52	638.4	541.1	53.4	53.6

Table 3: Effect of different rates of humic acid and nutrients on the cost of cultivation, gross return and B: C ratio of maize + cowpea intercropping

Treatments	Operational cost (Rs. ha^{-1})	Treatment cost (Rs. ha^{-1})	Total cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C Ratio
T1	17570.0	6805.2	24375.2	56130.0	31754.8	1.30
T2	17570.0	7635.2	25205.2	59450.0	34244.8	1.36
T3	17570.0	7463.9	25033.9	59750.0	34716.1	1.39
T4	17570.0	8295.2	25865.2	63650.0	37784.8	1.46
T5	17570.0	9126.5	26696.5	67470.0	40773.5	1.53
T6	17570.0	8123.9	25693.9	60290.0	34596.1	1.35
T7	17570.0	8955.2	26525.2	68530.0	42004.8	1.58
T8	17570.0	9786.5	27356.5	72160.0	44803.5	1.64
T9	17220.0	2493.9	19713.9	53460.0	33746.1	1.71
T10	17220.0	3325.2	20545.2	56600.0	36054.8	1.75
T11	17220.0	4156.5	21376.5	60560.0	39183.5	1.83
T12	16520.0	0.0	16520.0	36080.0	19560.0	1.18

Table 4: Effect of different rates of humic acid and nutrients on proximate composition of maize and cowpea green fodder

Treatment	Dry matter content (%)		Ash content (%)		Crude protein (%)		Crude fibre (%)		Crude fat (%)		Nitrogen Free Extract	
	Maize	Cowpea	Maize	Cowpea	Maize	Cowpea	Maize	Cowpea	Maize	Cowpea	Maize	Cowpea
T1	30.08	8.19	8.63	17.84	8.50	20.57	28.96	28.77	2.24	3.57	51.67	29.25
T2	30.74	8.44	8.91	18.35	8.90	20.58	28.68	27.24	2.26	3.81	51.25	30.02
T3	31.23	8.54	9.75	19.28	9.30	20.93	32.22	28.42	1.90	4.05	46.83	27.32
T4	32.32	8.91	10.32	20.19	10.40	21.24	31.31	27.49	2.01	4.14	45.96	26.94
T5	32.90	9.11	10.4	20.80	11.19	21.92	29.17	24.79	2.18	4.30	47.06	28.19
T6	32.26	8.95	10.63	20.64	10.58	20.75	30.17	26.09	2.06	4.11	46.56	28.41
T7	33.19	9.16	11.36	20.82	11.06	21.32	28.27	23.98	2.4	4.20	46.91	29.68
T8	34.77	9.22	12.48	21.89	11.85	22.42	23.97	22.03	2.65	4.45	49.05	29.21
T9	28.02	8.12	8.50	18.14	8.28	19.82	19.29	29.0	1.93	3.50	62.00	29.54
T10	29.10	8.22	8.72	18.81	8.45	20.32	18.05	28.18	2.14	3.71	62.64	28.98
T11	30.25	8.30	9.10	18.94	9.01	20.88	17.14	27.14	2.28	3.85	62.47	29.19
T12	26.90	7.83	7.28	15.76	7.89	18.73	20.2	30.57	1.69	3.03	62.94	31.91

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