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Productivity and nutritive value of fodder intercropping through humic acid nutrient management strategies

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Abstract
To study the response of humic acid and macronutrient doses on fodders, a research study was commenced at Department of agronomy, Agricultural College and Research Institute, Killikulam during 2021 cultivating fodder maize (African Tall) and fodder cowpea (CO 9) intercrops with application of humic acid and different fertilizer recommendation practices. The results concluded that treatment imposed with application of 125% RDF along with enriched farmyard manure and humic acid @ 20 kg ha^{-1} and foliar spray of 1.0% Urea + 0.5% $CaCl_2$ had significantly produced maximum quantity of green fodder and dry fodder yield, respectively under intercropping. The soil incorporation of humic acid along with enriched farmyard manure and different fertilizer dose increased the productivity significantly and also decreased the amount of fibre fractions present in the fodders, alternatively enhanced the nutritive values/ energy of fodder under cereal-pulse intercropping.

Keywords: Fodder maize, fodder cowpea, fodder quality, intercropping, humic acid, productivity

Introduction

Livestock management is the most viable and lucrative profession due to its ability to produce considerable cash income throughout the year. It is estimated that farmers spent almost 2/3 of the total cost for feeds/supplements during their livestock management. Ghosh *et al.* (2016) predicted that present deficit for fodder is holding to about 35.6% in case of green fodder, 10.95% of bulky dry fodders and crop residues, and 44% of nutrient rich concentrate. Deficit could also cause due to seasonal variations and regional production, where the excess of fodders cannot be transported to resources unavailable areas because of transport cost incurred for long distances. Cattle may be kept healthier and more productive by giving them high-quality feed, essential nutrients, and proper medical care. By intercropping fodder legumes with cereal fodder, the quality of the fodder was enhanced and the production of the land was increased. The intercrops' altered crop spacing allowed for a variety of intercropping patterns (Kumar and Narmadha 2018) [16].

According to Parihar (2010) [19], the quality of seeds/planting materials is found to be prominent constraints for decreased rate of area and productivity in fodder crops cultivation. Mainly these forage and fodder were produced for their maximum vegetative biomass potential, their yield production and productivity were considerably low. Hence fodder seed productions are not totally tamed, so their production and availability is quite critical. Most of the forages are multiplied by vegetative propagation and also perennial in nature (Vijay *et al.*, 2018) [27]. Many reasons contribute to the underutilization of the seed sector's potential, which may be classified as climatic, physiological, managerial, and policy-driven. Physiological constraints include indeterminate growth habit, unsynchronized fodder maturity, seed shattering nature, ill-filled or chaffy seeds, induced dormant seed, decreased tiller production, susceptibility to lodging, very lower harvest index; various climatic parameters include rainfall, drought, photoperiodism, humidity, temperature; minimum level of hybrid seed production technology for fodders, and the unavailability of specialized fodder seed market also limits the availability and production of seeds.

According to Khamkar (2016) [14], livestock provides continuous source of income for most of the rural people and 75% of farmers are small and marginal farmers. Indian cattle are less productive than the norm worldwide (Anonymous 2020) [1].

The primary causes of low productivity include: A lack of quality feed, its availability, breed genetic potential, etc. Because fodder crops provide 80-90% of the nutrients needed by cattle, so fodder quality is also important as much as fodder production. In India, fodder quality having deficit for 24.6% of crude protein (CP) and 19.9% of total digestible nutrients causing eye-opening for enhancing the fodder quality. According to some reports, it is predicted that the fodder quality can be enhanced by year 2030, with decreased deficit of 20.78% CP and 17.52% TDN followed by 16.81% and 15.47% of CP and TDN in 2050, respectively. The needful strategy to meet out deficits of CP, TDN, and dry fodder output is to improve qualitative fodder production. Agronomically, the productivity, production and quality of the fodder can be increased by choosing the right crop, cultivars, and nutrient management techniques. Higher productivity is generally recognized for cereal crops. Among them, *Zea mays* L. is a common kharif fodder crop with igh yield potential in both case of grain yield and biomass output (Kumar *et al*. 2019) [15]. Maize can adapt to a variety of agroclimatic conditions and is primarily used for grain and feed. The crop productivity of any cereal crop can be significantly increased by enhancing the soil fertility by addition of bulky organic manures (Bandyopadhyay *et al.* 2010) [4]. Plant growth-promoting rhizobacteria (PGPR) plays an important role in augmenting the crop growth rate and sustaining the yield production. Humic acid can be used as organic manure or as biostimulant that contains macro and micronutrients, growth promotors and other mutualistic beneficial microbes, could fix the available nutrients to plants by marinating adequate soil solution near the root zone results in increased nutrient uptake and their efficiency, consequently enhances the nutritive values, proximate composition and productivity (Kumar *et al*. 2021) [8].

Materials and Methods

Site description: A field experiment was conducted at Agricultural College and Research Institute, Killikulam during *summer* 2021 to study the effect of humic acid, macronutrient and foliar treatment on yield productivity and nutritive value of fodder crops. The initial soil sample of the experimental field was analysed and found to be *p*H value of 7.3, electrical conductivity value of 0.08 dS/m and 0.45% organic carbon. The initial total soil available was recorded as 202:14:240 NPK kg/ha.

Experimental design, treatments and crop management

The experiment was laid out by using randomized block design (RBD) with three replications. Twelve treatment combinations of T_1 – 100% RDF + Foliar spraying of 1.0% MAP + 0.5% $CaCl_2$; T_2 - 100% RDF + Enriched FYM + Foliar spraying of 1.0% Urea + 0.5% $CaCl_2$; T_3 - 75% RDF + Enriched FYM + 10 kg ha^{-1} HA + Foliar spraying of 1.0% Urea + 0.5% $CaCl_2$; T_4 - 100% RDF + Enriched FYM + 10 kg ha^{-1}HA + Foliar spraying of 1.0% Urea + 0.5% $CaCl_2$; T_5 - 125% RDF + Enriched FYM + 10 kg ha^{-1} HA + Foliar spraying of 1.0% Urea + 0.5% $CaCl_2$; T_6 - 75% RDF + Enriched FYM + 20 kg ha^{-1} HA + Foliar spraying of 1.0% Urea + 0.5% $CaCl_2$; T_7 - 100% RDF + Enriched FYM + 20 kg ha^{-1} HA + Foliar spraying of 1.0% Urea + 0.5% $CaCl_2$; T_8 - 125% RDF + Enriched FYM + 20 kg ha^{-1} HA + Foliar spraying of 1.0% Urea + 0.5% $CaCl_2$; T_9 - 75% RDF; T_{10} - 100% RDF; T_{11}- 125% RDF; T_{12}- absolute control were taken for study. Recommended dose of enriched FYM @ 750 kg/ha was applied before sowing. Recommended dose of fertilizers @ 60:40:20 NPK kg/ha through urea, single super phosphate and muriate of potash were applied. Half of N and full dose of P_2O_5 and K_2O was applied as basal and remaining half dose of nitrogen was applied at 30 DAS. Foliar application of 1.0% urea and 2.0% $CaCl_2$ is given at 45 DAS.

Fodder quality analysis: Plant samples i.e., green fodders were collected after the harvest of the crop. The collected samples were first shade dried and then oven-dried at 65ºC until attaining the constant weight, where the moisture gets lost and dry fodder can be obtained. Then, they were finely ground using Willey mill and used for the estimation of Crude protein % (CP), Ether Extract % (EE) and Total Ash % (TA) and their yields were obtained by multiplying their % content with total yield (AOAC 2005) [2]. Total carbohydrate (T-CHO) present in the fodder can be derived from subtracting the sum total of CP, EE and TA from 100. T-CHO contains both Structural (SC) and non-structural carbohydrates (NSC) which can also be derived from the formulae given below. Nutritional values of fodder such as digestible crude protein (DCP), dry matter intake (DMI), dry matter digestibility (DMD), total digestible nutrients (TDN) and net energy for lactation (NEl) were estimated using following equations.

NSC (%) = 100 – [CP%+EE + (NDF% – NDICP %) + TA%] (Das *et al*. 2015)

SC (%) = T–CHO%–NSC% (Das *et al*. 2015) [7]

DCP (%) = (0.929×CP%)-3.52

DMI (%) =120/*NDF*% (Horrocks and Vallentine 1999) [10]

DMD (%) = 88.9-(0.779×ADF %) (Horrocks and Vallentine 1999) [10]

TDN (%) = (–1.291×ADF %) + 101.35 (Horrocks and Vallentine 1999) [10]

NEl (Mcal/kg) = [1.044-(0.0119 × ADF%] × 2.205 (Horrocks and Vallentine 1999) [10]

Results and Discussion

Green fodder and Dry fodder yield

Application of 125% RDF along with enriched FYM and 20 kg ha^{-1} HA and foliar spray of 1.0% Urea + 0.5% $CaCl_2$ (T_8) significantly recorded the maximum green forage yield of 35.14 t ha^{-1}, followed by 100% RDF along with enriched FYM and 20 kg ha^{-1} HA and foliar spray of 1.0% Urea + 0.5% $CaCl_2$ (T_7) which yielded about 33.53 t ha^{-1}. Among the treatments, absolute control plot (T_{12}) recorded the lower dry fodder yield of 21.07 t ha^{-1}. After harvesting of the crop, the maximum dry fodder yield (5.27 t ha^{-1}) was obtained in the treatment imposed with the application of 125% RDF along with enriched FYM and 20 kg ha^{-1} humic acid and foliar spray of 1.0% Urea + 0.5% $CaCl_2$ (T_8) followed by the treatment, 100% RDF along with enriched FYM and 20 kg ha^{-1} HA and foliar spray of 1.0% Urea + 0.5% $CaCl_2$ (T_7) which recorded a yield of 5.03 t ha^{-1}. The absolute control plot (T_{12}) recorded the lower dry fodder yield of 3.16 t ha^{-1}.

The total fresh forage yield of the maize and cowpea under paired row intercropping system was highly influenced by the humic acid application, enriched FYM, fertilizer levels and foliar treatments. The highest total fresh forage yield of fodder maize (35.14 t/ha) and cowpea (18.51 t/ha) was significantly produced in 125% RDF along with enriched FYM and 20 Kg ha^{-1} HA and foliar spray of 1.0% Urea + 0.5% $CaCl_2$ (T_8). Increasing nitrogen levels significantly increased the total fresh forage yield by increasing vegetative growth that led to more dry matter partitioning (Shahid 2012) [22]. Apart from the nitrogen role, phosphorus also increased the number of leaves, plant height and leaf area that increased the fodder yield.

Intercropping of maize with cowpea increased fodder production and productivity as it fixed the atmospheric nitrogen through root nodules (Iqbal *et al.*, 2018; Pathak *et al.*, 2013) [11, 20]. Humic acid also increased the efficiency of uptake and translocation of nitrogenous compounds to the sources, thus increasing the production of green fodder yield (Sao *et al.*, 2004) [21]. Under paired row system, the maximum plant population per unit area obtained by closer spacing also increased the fodder yield (Jadav *et al.*, 2018) [29]. The total dry matter yield of maize and cowpea under paired row intercropping was found to be significantly influenced by the humic acid application, enriched FYM, fertilizer levels and foliar treatments. The maximum total dry forage yield of fodder maize (5.27 t/ha) and cowpea (2.77 t/ha) produced in 125% RDF along with enriched FYM and 20 Kg ha^{-1} HA and foliar spray of 1.0% Urea + 0.5% $CaCl_2$ (T_8) was significantly different. Increased nitrogen and humic acid levels significantly increased the total dry matter content of forage crops (Baghdadi *et al.*, 2016; Ayub *et al.*, 2009) [5, 3]. Usually, legumes intercropped with maize would enhance fodder and land productivity (Javanmard *et al.*, 2009) [13]. Under paired row system, plant population per unit area was increased which consequently increased the total dry matter production. (Javanmard *et al.*, 2009; Sao *et al.*, 2004) [13, 21].

Nutritive value of fodder

Nutrient management strategies such as humic acid and various fertilizer doses caused variations in fibre fractions. The amount of fibre content in fodder maize was affected by application of fertilizer caused decrement when applied with humic acid when compared to non-application of humic acid and control plots. In case of fodder legume, fibre fractions were not highly influenced by humic acid and fertilizer application but compared with control had more fibre content. Fibre fractions such as NDF, ADF and ADL were found to be negatively correlated with CPY, EEY and TAY, these results confirmed that the decreased fibre content when applied with organic and inorganic fertilizers could hasten mineralization or solubilization of nutrients to become available form such that their efficiency of uptake can be increased by the crops. The results were in accordance with the fact that increased application N reduces the fibre fractions (Yadav *et al.* 2007) [28].

The T-CHO content also varied with humic acid and fertilizer dose, whereas NSC and SC content also changed variably. SC content and carbohydrates fractions were higher in treatments with humic acid application @ 10 kg/ha when compared with treatment containing 20 kg/ha humic acid. This decrement in carbohydrate fraction was found when humic acid rate was increased consequently the amount of carbohydrate fractions were higher in cases of humic acid not applied plots. It is also found that increasing the fertilizer content also reduced the TCHO content in African Tall and CO 9 cultivars. Carbohydrate fractionation in both cereal and legume fodder revealed that more CP accumulation under treatments resulted lower T-CHO content. It also had a fact that Crude Protein Yield and total carbohydrate content were negatively correlated with each other. Case studies reported that Non Structural Carbohydrate can be easily digestible when compared with structural carbohydrates and Crude Protein (Das *et al.* 2015) [7]. Crude protein content was directly related to nitrogen content. Crude protein content was increased by increasing the N level and humic acid application (Shahid 2012; Saruhan *et al.*, 2011) [22, 24].

For dry matter intake (DMI), all the treatments containing both humic acid and fertilizer were observed to be increasing and eventually at par each other. DMD was found to be increasing at 20 kg/ha humic acid application with higher dose of fertilizer application, but it was lower than the value of treatment imposing only recommended dose. Alternatively, TDN was found to be higher with the treatments containing humic acid application along with recommended fertilizer than alone. It was also found that treatments with both combination of humic acid and fertilizer dose enhanced the DMD, TDN and NEI content compared with control. The fact given that negative correlation of DMI and TDN with NDF content, whereas DMD and NEI with ADF content. Therefore, decreased NDF content would lead to increased DMI and TDN. Hence, it is concluded that the reduction in fibre content under humic acid and fertilizer dose plots would lead to improved values of DMI, DMD, TDN and NEl (Salama and Zeid, 2016) [23].

Table 1: Effect of humic acid, fertilizer levels and foliar treatment on green fodder yield and dry fodder yield (t ha^{-1}) under intercropping

	Treatments	Green fodder yield (t ha^{-1})		Dry fodder yield (t ha^{-1})	
		Fodder maize	Fodder cowpea	Fodder maize	Fodder cowpea
T_1	100% RDF + Foliar 1.0% MAP + 0.5% $CaCl_2$	27.39	14.37	4.11	2.15
T_2	100% RDF + Enriched FYM + Foliar 1.0% Urea + 0.5% $CaCl_2$	29.25	15.1	4.38	2.26
T_3	75% RDF + Enriched FYM + 10 kg HA + Foliar 1.0% Urea + 0.5% $CaCl_2$	29.81	14.97	4.47	2.24
T_4	100% RDF + Enriched FYM + 10 kg HA + Foliar 1.0% Urea + 0.5% $CaCl_2$	31.75	15.95	4.76	2.39
T_5	125% RDF + Enriched FYM + 10 kg HA + Foliar 1.0% Urea + 0.5% $CaCl_2$	33.13	17.17	4.97	2.57
T_6	75% RDF + Enriched FYM + 20 kg HA + Foliar 1.0% Urea + 0.5% $CaCl_2$	29.75	15.27	4.46	2.29
T_7	100% RDF + Enriched FYM + 20 kg HA + Foliar 1.0% Urea + 0.5% $CaCl_2$	33.53	17.5	5.03	2.62
T_8	125% RDF + Enriched FYM + 20 kg HA + Foliar 1.0% Urea + 0.5% $CaCl_2$	35.14	18.51	5.27	2.77
T_9	75% RDF	25.92	13.77	3.89	2.06
T_{10}	100% RDF	27.34	14.63	4.10	2.19
T_{11}	125% RDF	28.42	16.07	4.26	2.41
T_{12}	Absolute control	21.07	11.8	3.16	1.77
	S.Ed	0.64	0.26	1.04	0.35
	CD (P=0.05)	1.34	0.55	2.17	0.74

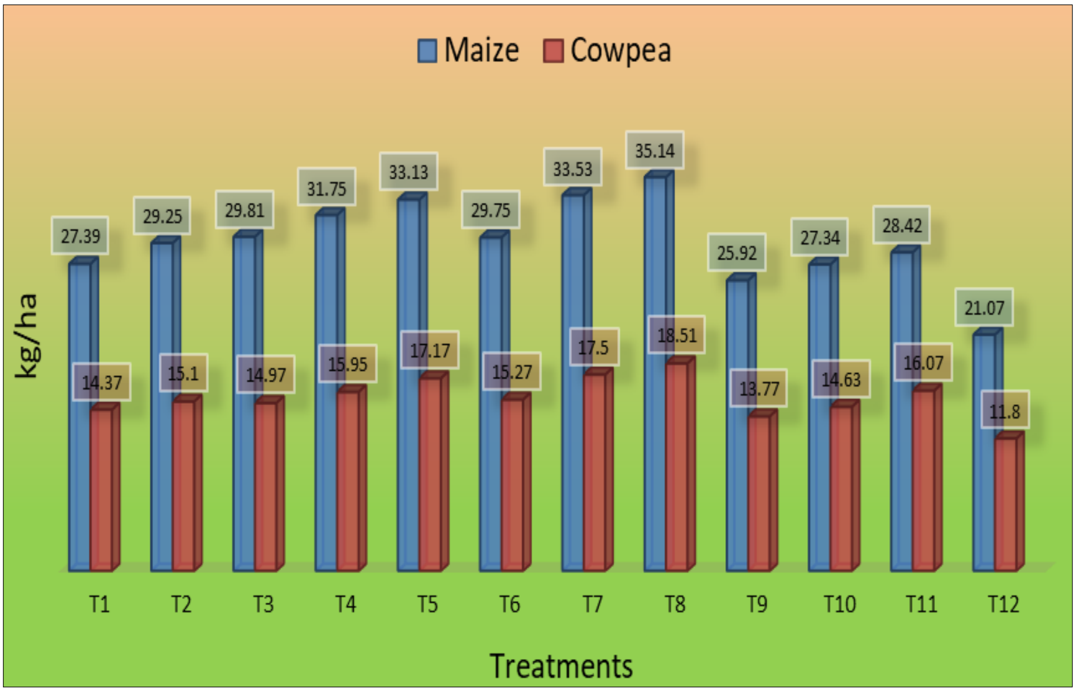
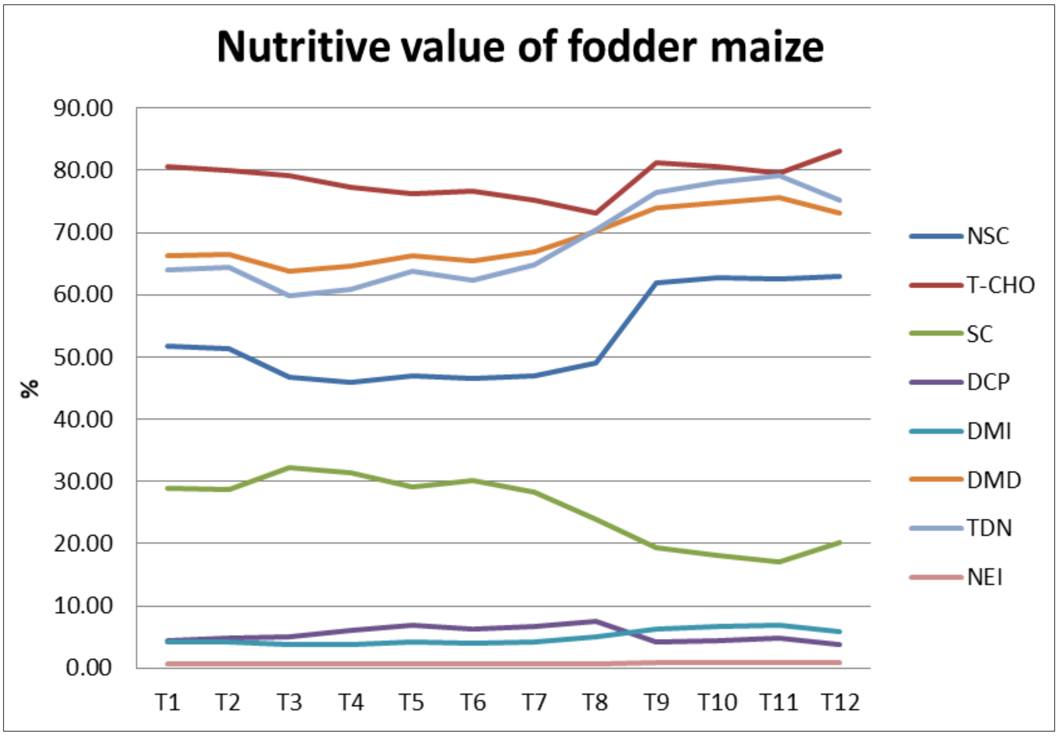


Fig 1: Effect of humic acid, fertilizer levels and foliar treatment on green fodder yield (t ha^{-1}) under intercropping

Table 2 Effect of humic acid, fertilizer levels and foliar treatment on nutritive value of fodder maize and fodder cowpea under intercropping

	NSC (%)		T-CHO (%)		SC (%)		DCP (%)		DMI (%)		DMD (%)		TDN (%)		NEI (%)	
	Fodder Maize	Fodder Cowpea	Fodder Maize	Fodder Cowpea	Fodder Maize	Fodder Cowpea	Fodder Maize	Fodder Cowpea	Fodder Maize	Fodder Cowpea	Fodder Maize	Fodder Cowpea	Fodder Maize	Fodder Cowpea	Fodder Maize	Fodder Cowpea
T_1	51.67	29.25	80.63	58.02	28.96	28.77	4.38	15.59	4.14	4.17	66.34	66.49	63.96	64.21	0.70	0.70
T_2	51.25	30.02	79.93	57.26	28.68	27.24	4.75	15.60	4.18	4.41	66.56	67.68	64.32	66.18	0.70	0.72
T_3	46.83	27.32	79.05	55.74	32.22	28.42	5.12	15.92	3.72	4.22	63.80	66.76	59.75	64.66	0.66	0.71
T_4	45.96	26.94	77.27	54.43	31.31	27.49	6.14	16.21	3.83	4.37	64.51	67.49	60.93	65.86	0.67	0.72
T_5	47.06	28.19	76.23	52.98	29.17	24.79	6.88	16.84	4.11	4.84	66.18	69.59	63.69	69.35	0.70	0.75
T_6	46.56	28.41	76.73	54.50	30.17	26.09	6.31	15.76	3.98	4.60	65.40	68.58	62.40	67.67	0.68	0.73
T_7	46.91	29.68	75.18	53.66	28.27	23.98	6.75	16.29	4.24	5.00	66.88	70.22	64.85	70.39	0.71	0.76
T_8	49.05	29.21	73.02	51.24	23.97	22.03	7.49	17.31	5.01	5.45	70.23	71.74	70.40	72.91	0.76	0.78
T_9	62.00	29.54	81.29	58.54	19.29	29.00	4.17	14.89	6.22	4.14	73.87	66.31	76.45	63.91	0.81	0.70
T_{10}	62.64	28.98	80.69	57.16	18.05	28.18	4.33	15.36	6.65	4.26	74.84	66.95	78.05	64.97	0.83	0.71
T_{11}	62.47	29.19	79.61	56.33	17.14	27.14	4.85	15.88	7.00	4.42	75.55	67.76	79.22	66.31	0.84	0.72
T_{12}	62.94	31.91	83.14	62.48	20.20	30.57	3.81	13.88	5.94	3.93	73.16	65.09	75.27	61.88	0.80	0.68



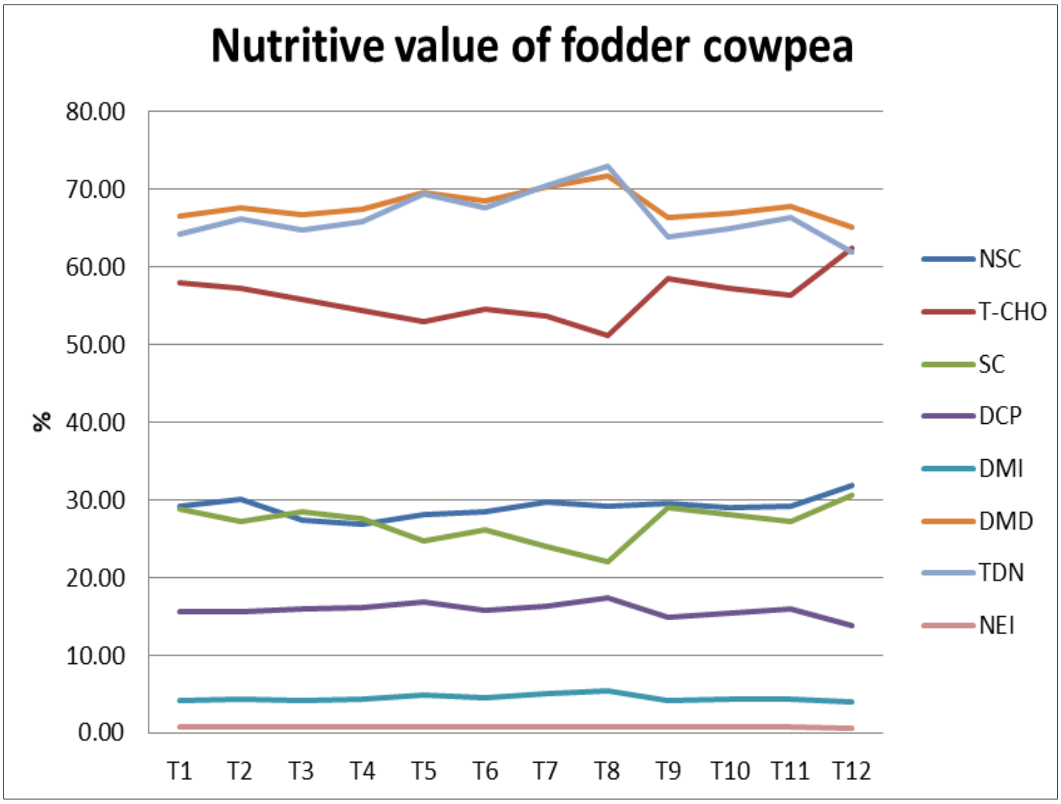


Fig 2: Effect of humic acid, fertilizer levels and foliar treatment on nutritive value of fodder maize and fodder cowpea under intercropping

Conclusion

From this experimental study, it has proven that under intercropping of fodder maize and fodder cowpea along with application of 125% RDF + Enriched FYM + 20 kg HA + Foliar 1.0% Urea + 0.5% $CaCl_2$ increased the fodder productivity, quality and reduced the fibre fractions.

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