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Dynamics in nutritive value of fodder crops under hydroponics as influenced by nutrient foliar spray

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Abstract
The experiment was conducted at New area Farm, Department of Forage crops, Tamil Nadu Agricultural University, Coimbatore, to evaluate dynamics in nutritive value of fodder crops under hydroponics as influenced by nutrient foliar spray during October - December 2017. The treatments included two factors *viz*. crops- fodder maize (C_1), grain maize (C_2), grain cowpea (C_3) and horse gram (C_4) and foliar nutrition- control (without any spray) (N_0), 19: 19: 19 @ 1% (N_1), DAP @ 0.5% + KCL @ 0.5% (N_2), panchagavya @ 3% (N_3), and vermiwash @ 1% (N_4). From this study, it can be concluded that growing of grain maize with foliar application of 19:19:19 NPK @ 1% found to be technically viable and economically feasible option for attaining maximum green fodder yield and nutritional quality under hydroponic fodder production system.

Keywords: Hydroponics, shoot length, chlorophyll content, crude fibre, crude fat, foliar spray

Introduction
Feeding of quality green fodder to dairy animals could play an important role in sustainable and economical dairy farming. However, various constraints are faced by the dairy farmers for production of green fodder like small land holdings, unavailability of land for fodder cultivation, scarcity of water or saline water, non availability of good quality fodder seeds, more labour requirement, requirement of manure and fertilizer, longer growth period (45-60 days), fencing to prevent fodder crop from wild animals, natural calamities etc. Furthermore, the non-availability of constant quality of fodder round the year aggravates the limitations of the sustainable dairy farming. Due to the above constraints and the problems faced in the conventional method of fodder cultivation, hydroponics is now emerging as an alternative technology to grow fodder for farm animals (Naik *et al.* 2011) [9]. Hydroponics fodder is palatable and the germinated seeds embedded in the root system are also consumed along with the shoots of the plants without any nutrient wasting (Pandey and Pathak, 1991) [12]. Sometimes, animals take the leafy parts of the hydroponics fodder and the roots portions are not consumed which can be avoided by mixing the hydroponics fodder with the other roughage components of the ration (Reddy *et al.*, 1988, Naik and Singh 2014) [14, 10]. There are changes in the nutrient content of the cereal grains and hydroponics fodder (Hillier and Perry 1969; Peer and Leeson 1985). The DM (89.7 vs. 13.4%) and OM (96.60- 97.19 vs. 96.35%) content is decreased which may be due to the decrease in the starch content. The nutrient contents of hydroponics fodder are superior to certain common non-leguminous fodders but comparable to leguminous fodders (Reddy *et al*., 1988; Pandey and Pathak, 1991) [14, 12] in terms of available OM, CP, EE and NFE content. Keeping the above points in view, the present study was mooted with to study the dynamics in nutritive value of fodder crops under hydroponics as influenced by nutrient foliar spray.

Materials and Methods
The experiment was conducted at 'F' block of New area Farm, Department of Forage crops, Tamil Nadu Agricultural University, Coimbatore, during October - December 2017. The experimental site located in the western agro climatic zone of Tamil Nadu at 11ºN latitude and 77ºE longitudes and at an altitude of 426.7 m above the mean sea level. The experiment was The experiment was laid out in factorial completely randomized design, comprised of four crops *viz*, fodder maize(C_1), grain maize (C_2), grain cowpea (C_3) and horse gram

(C_4) and five sources of foliar nutrition control (without any spray) (N_0), 19: 19: 19 @ 1% (N_1), DAP @ 0.5% + KCL @ 0.5% (N_2), panchagavya @ 3% (N_3), and vermiwash @ 1% (N_4). The twenty treatment combinations were replicated thrice and the experiment repeated by four times. Low cost hydroponic chamber having the size of 20' length x 10' width x 10' height was established with available once used GI pipes and wooden reapers. The shill out was covered with shade net of 70 percent shading capacity. Wooden racks (10' length x 3' width x 5' height) were fabricated to hold the hydroponic plastic trays (1260 cm^2). Drainage holes were made at the bottom of trays to facilitate drainage of excess water. Single phase half HP motor was used to deliver the water from water tank through 16 mm laterals fitted with low cost foggers at 75 cm distance. Observations on growth parameter *viz*. shoot length were taken on 2nd, 4th, 6th, and 8th day of seeding of crops, respectively. Physiological parameter *viz*. Chlorophyll index measured by chlorophyll meter from Minolta (model 502 of Minolta Japan) from five randomly selected seedlings in each tray from 3rd day to 8th day of seeding. The procedure suggested by Minolta (1989) [8].

Quality parameters such as crude fibre content was estimated gravimetrically by successive digestion and washing of a weighed portion of the plant sample with dilute acid and alkali suggested by Goering and Van Soest (1970) [4]. The material left undigested was considered as crude fibre and expressed in percentage. Crude fat content was determined according to the method of A.O.A.C (1970) [1] and expressed in percentage. Crude fibre yield and crude fat yield were computed by multiplying the crude fibre and crude fat content with the respective dry matter production and expressed in g kg^{-1} of seeds. The cost of cultivation, gross return, net return and benefit cost ratio were calculated on the basis of prevailing market price of different inputs and outputs. Observations from four trials were subjected to pooled data analysis technique, the pooled data were statistically analyzed based on the procedure given by Gomez and Gomez (1984) [5]. Pooled and individual trial wise data for the parameters *viz.*, crude fibre content, crude fat content, crude fibre yield, crude fat yield, are detaily furnished. While, pooled data for the parameters *viz*., shoot length, chlorophyll index, are given.

Results and Discussion

Growth parameter

Shoot length

The pooled data of all the four trials pertaining to the shoot length are presented in the table 1. Different crops had no impact on shoot length at different crop growth periods.

Among the different foliar treatments, significant difference was observed from 6th day of seeding onwards. In which, foliar application of 19: 19: 19 @ 1% (N_1) recorded significantly higher shoot length of 23.40 and 27.67 cm at 6th and 8th day of seeding, respectively. It was followed by DAP @ 0.5% + KCL @ 0.5% (N_2) which registered the shoot length of 20.26 and 25.51 cm on 6th and 8th day of seeding, respectively. However, control (without any spray) (N_0) recorded the lowest shoot length of 18.12 and 23.66 cm on 6th and 8th day of seeding, respectively. It was on par with vermivash @ 1% (N_4) with 18.23 and 23.73 cm and panchagavya @ 3% (N_3) with 18.32 and 23.80 cm on 6th and 8th day of seeding, respectively. There was no significant interaction between crops and foliar nutrition spray on shoot length. The current findings are also in line with the findings of (Ansari, 2008) [2].

Physiological parameter

Chlorophyll index (SPAD reading)

The SPAD meter readings were recorded from 3rd day of crop growth and are presented in table 2. Remarkable variation in chlorophyll index was observed from 5th day of crop growth due to crops and foliar nutrition under hydroponic fodder cultivation system. Among the crops, higher chlorophyll index was registered in grain cowpea (C_3) with 35.30, 38.54, 40.67 and 41.66 on 5th day, 6th day, 7th day and 8th day of seeding, respectively. It was on par with horse gram (C_4) which also recorded the chlorophyll index of 35.30, 38.51, 40.63 and 41.61 on 5th day, 6th day, 7th day and 8th day of seeding, respectively. Castro and Sanchez-Azofeifa (2008) also noticed the similar observations. Whereas lower chlorophyll index was registered in fodder maize (C_1) and grain maize (C_2) this is conformity with the study conducted by Verma *et al.* (2015) [15]. Among the foliar nutrition, significantly higher chlorophyll index of 36.08, 38.54, 41.14 and 42.16 during 5th day, 6th day, 7th day and 8th day of seeding, respectively were registered with application 19: 19: 19 @ 1% (N_1). It was followed by DAP @ 0.5% + KCL @ 0.5% (N_2) which recorded the chlorophyll index of 34.03, 36.79, 38.62 and 39.27 during 5th, 6th, 7th and 8th day of seeding, respectively. Hokmalipour and Darbandi (2011) [7] also recorded higher chlorophyll index with external application of nitrogen through foliage. Lower chlorophyll index was observed in control (without any spray) (N_0) which recorded 31.79, 34.03, 36.09 and 37.06 of chlorophyll index during 5th, 6th, 7th and 8th day of seeding, respectively. It was on par with Panchagavya @ 3% (N_3) (31.82, 34.11, 36.12 and 37.11 on 5th, 6th, 7th and 8th day of seeding, respectively.) and vermivash @ 1% (N_4) (31.81, 34.08, 36.10 and 37.08 during 5th, 6th, 7th and 8th day of seeding, respectively.)

However, crops and foliar nutrient spray did not show any interaction effect.

Quality parameters

Crude fibre content

Crude fibre content was not significantly differed with different crops and foliar nutrition under the study. The data are furnished in table 3.

Crude fibre yield

There was no appreciable difference in crude fibre yield due to crops selected for hydroponic system. However, different nutrient foliar spray had a significant impact on crude fibre yield (Table 4).

Foliar spray of 19: 19: 19 @ 1% (N_1) resulted higher crude fibre yield of 56.61, 56.88, 57.39 and 58.20 g CFY kg^{-1} of seeds during first, second, third and fourth trial, respectively. It was followed by DAP @ 0.5% + KCL @ 0.5% (N_2) which recorded the crude fibre yield of 52.03, 52.08, 52.33 and 53.45 g CFY kg^{-1} of seeds during first, second, third and fourth trial, respectively. However, lower crude fibre yield was registered in panchagavya @ 3% (N_3) with 48.03, 48.42, 47.59 and 48.67 g CFY kg^{-1} of seeds, vermivash @ 1% (N_4) with 47.49, 47.15, 47.61 and 48.03 g CFY kg^{-1} of seeds and control (without any spray) (N_0) with 47.25, 46.82, 46.33 and 47.34 g CFY kg^{-1} of seeds during first, second, third and fourth trial, respectively.

Pooled analysis also revealed that there was no significant difference in the crude fibre yield with respect to crops selected. Among the nutrient foliar spray, significantly higher crude fibre yield of 57.27 g CFY kg^{-1} of seed was registered in 19: 19: 19 @ 1% (N_1) and it was followed by DAP @ 0.5%

+ KCL @ 0.5% (N_2) which recorded 52.47 g CFY kg^{-1} of seed. Zambre *et al.* (2016) [16] also noticed the higher crude fibre yield with external supply of macro nutrients. However, lower crude fibre yield of 46.93 g CFY kg^{-1} of seed was noticed in control (without any spray) (N_0). It was on par with panchagavya @ 3% (N_3) with 48.18 g CFY kg^{-1} of seed and vermivash @1% (N_4) with 47.57 g CFY kg^{-1} of seed.
Interaction effect was not observed in crude fibre yield due to crops and nutrient foliar spray.

Crude fat content
Crops used and different sources of foliar spray did not show any significant difference in crude fat content (Table 5).

Crude fat yield
Distinct difference was not observed due to different crops with respect to crude fat yield. However, discernible variations were showed on crude fat yield due to different foliar spray. It was calculated and presented in table 6.
Among the foliar nutrition, spraying of 19: 19: 19 @ 1% (N_1) recorded higher crude fat yield of 56.50, 56.13, 56.86 and 57.34 g crude fat yield kg^{-1} of seeds during first, second, third and fourth trial, respectively. It was followed by DAP @ 0.5% + KCL @ 0.5% (N_2) having 52.08, 52.01, 52.34 and 53.45 g of crude fat kg^{-1} of seeds during first, second third and fourth trial, respectively. However, lowest crude fat yield of 48.25, 47.46, 47.05 and 48.07 g of crude fat kg^{-1} of seeds were recorded in control (without any spray) (N_0). It was on par with panchagavya @ 3% (N_3) with 48.89, 48.86, 48.22 and 49.26 g of crude fat kg^{-1} of seeds and vermivash @ 1% (N_4) with 48.47, 47.70, 48.41 and 48.81 g of crude fat yield kg^{-1} of seeds during first, second, third and fourth trial, respectively.
Pooled analysis also confirmed that there was no significant difference was recorded in the crude fat yield by selected crops under hydroponics. Among the foliar spray significantly higher crude fat yield of 56.71 g crude fat kg^{-1} of seed was recorded with application of 19: 19: 19 @ 1% (N_1). The probable reason might be higher growth and dry matter production which led to higher crude fat yield. This is in agreement with the findings of Naik *et al.* (2015) [11]. It was followed by DAP @ 0.5% + KCL @ 0.5% (N_2) which recorded 52.47 g of crude fat kg^{-1} of seed. However, panchagavya @ 3% (N_3), vermivash @ 1% (N_4) and control (without any spray) (N_5) were resulted the lowest crude fat yield of 48.81,48.35 and 47.71 g of crude fat kg^{-1} of seed, respectively.
There was no interaction effect was observed between crops and nutrient foliar spray with respect to crude fat yield.

Economics
The results (Table. 7) of the investigation clearly indicated that grain maize with foliar spray of 19:19:19 NPK @ 1% (C_2N_1) recorded higher B:C ratio of 1.16. This was closely followed by grain maize along with foliar application of DAP @ 0.5% + KCL @ 0.5% (N_2) (C_2N_2) which registered the B:C ratio of 1.15.

Conclusion
From the study it could be concluded that cultivation of grain maize with foliar application of 19:19:19 @ 1% found to be the best option for attaining maximum green fodder yield and nutritional quality with minimal cost under hydroponic fodder production system.

Table 1: Effect of crops and nutrient foliar spray on shoot length (cm) (Four trials pooled)

Treatments / Days	2nd	4th	6th	8th
Crops				
C_1	3.06	9.79	20.08	25.72
C_2	3.04	9.68	19.63	25.07
C_3	2.98	9.57	19.52	24.43
C_4	2.96	9.52	19.45	24.27
S. Em±	0.08	0.12	0.25	0.61
CD (P = 0.05)	NS	NS	NS	NS
Nutrients				
N_0	3.01	9.64	18.13	23.66
N_1	3.02	9.63	23.40	27.67
N_2	3.00	9.64	20.26	25.51
N_3	3.01	9.65	18.32	23.80
N_4	3.01	9.64	18.23	23.73
S. Em±	0.09	0.13	0.28	0.68
CD (P = 0.05)	NS	NS	0.58	1.39
(Interaction) C x N				
S. Em±	0.18	0.27	0.57	1.37
CD (P = 0.05)	NS	NS	NS	NS

Time of nutrient foliar spray 4th, 5th, and 6th DAS

Table 2: Effect of crops and nutrient foliar spray on under hydroponics chlorophyll index under hydroponics (Four trials pooled)

Treatments / Days	3rd	4th	5th	6th	7th	8th
Crops						
C_1	22.37	24.79	28.28	32.49	34.59	35.45
C_2	22.01	24.89	28.27	32.50	34.57	35.43
C_3	22.94	24.93	35.30	38.54	40.67	41.66
C_4	22.84	24.92	35.30	38.51	40.63	41.61
S. Em±	0.46	0.57	0.78	0.76	0.69	0.93
CD (P = 0.05)	NS	NS	1.59	1.53	1.40	1.89
Nutrients						
N_0	22.32	24.94	31.79	34.03	36.09	37.06
N_1	22.86	24.80	36.08	38.54	41.14	42.16
N_2	22.67	24.90	34.03	36.79	38.62	39.27
N_3	22.36	24.91	31.82	34.11	36.12	37.11
N_4	22.48	24.87	31.81	34.08	36.10	37.08
S. Em±	0.51	0.64	0.88	0.85	0.77	1.04
CD (P = 0.05)	NS	NS	1.78	1.72	1.57	2.11
(Interaction) C x N						
S. Em±	1.03	1.28	1.76	1.70	1.55	2.09
CD (P = 0.05)	NS	NS	NS	NS	NS	NS

Time of nutrient foliar spray 4th, 5th, and 6th DAS

Crops			Nutrients		
C_1	-	Fodder maize	N_0	-	Control (without any spray)
C_2	-	Grain maize	N_1	-	19:19:19 @ 1%
C_3	-	Grain cowpea	N_2	-	DAP @ 0.5 % + KCL @ 0.5%
C_4	-	Horse gram	N_3	-	Panchagavya @ 3%
			N_4	-	Vermivash @ 1%

Table 3: Effect of crops and nutrient foliar spray on crude fibre content (per cent) under hydroponics

Treatments / Trials	First	Second	Third	Fourth	Pooled mean
Crops					
C_1	7.22	7.25	7.23	7.26	7.24
C_2	7.19	7.23	7.21	7.23	7.22
C_3	7.11	7.17	7.14	7.12	7.13
C_4	7.15	7.22	7.19	7.20	7.19
S. Em±	0.20	0.20	0.18	0.19	0.10
CD (P = 0.05)	NS	NS	NS	NS	NS
Nutrients					
N_0	7.09	7.13	7.11	7.11	7.11
N_1	7.29	7.37	7.33	7.36	7.34
N_2	7.25	7.26	7.25	7.24	7.25
N_3	7.12	7.18	7.15	7.16	7.15
N_4	7.10	7.16	7.13	7.13	7.13
S. Em±	0.22	0.22	0.20	0.22	0.11
CD (P = 0.05)	NS	NS	NS	NS	NS
(Interaction) C x N					
S. Em±	0.45	0.45	0.40	0.44	0.22
CD (P = 0.05)	NS	NS	NS	NS	NS

Time of nutrient foliar spray 4th, 5th, and 6th DAS, CFC – crude fibre content.

Table 4: Effect of crops and nutrient foliar spray on crude fibre yield (g CFY kg^{-1} of seed) under hydroponics

Treatments / Trials	First	Second	Third	Fourth	Pooled mean
Crops					
C_1	51.26	50.91	50.62	51.56	51.09
C_2	49.95	50.94	50.84	51.45	50.80
C_3	49.87	49.55	49.34	50.41	49.79
C_4	50.05	49.68	50.19	51.12	50.26
S. Em±	2.07	1.90	1.65	1.69	0.87
CD (P = 0.05)	NS	NS	NS	NS	NS
Nutrients					
N_0	47.25	46.82	46.33	47.34	46.93
N_1	56.61	56.88	57.39	58.20	57.27
N_2	52.03	52.08	52.33	53.45	52.47
N_3	48.03	48.42	47.59	48.67	48.18
N_4	47.49	47.15	47.61	48.03	47.57
S. Em±	2.31	2.12	1.84	1.89	0.97
CD (P = 0.05)	4.68	4.29	3.72	3.82	1.96
(Interaction) C x N					
S. Em±	4.63	4.25	3.69	3.78	1.94
CD (P = 0.05)	NS	NS	NS	NS	NS

Time of nutrient foliar spray 4th, 5th, and 6th DAS, CPY – Crude fibre yield

Crops			Nutrients		
C_1	-	Fodder maize	N_0	-	Control (without any spray)
C_2	-	Grain maize	N_1	-	19:19:19 @ 1%
C_3	-	Grain cowpea	N_2	-	DAP @ 0.5 % + KCL @ 0.5%
C_4	-	Horse gram	N_3	-	Panchagavya @ 3%
			N_4	-	Vermivash @ 1%

Table 5: Effect of crops and nutrient foliar spray on crude fat content (per cent) under hydroponics

Treatments / Trials	First	Second	Third	Fourth	Pooled mean
Crops					
C_1	7.26	7.25	7.24	7.24	7.25
C_2	7.25	7.24	7.25	7.242	7.24
C_3	7.25	7.25	7.24	7.248	7.25
C_4	7.25	7.25	7.24	7.236	7.24
S. Em±	0.16	0.15	0.17	0.18	0.08
CD (P = 0.05)	NS	NS	NS	NS	NS
Nutrients					
N_0	7.24	7.23	7.22	7.22	7.23
N_1	7.27	7.27	7.26	7.26	7.26
N_2	7.25	7.25	7.26	7.24	7.25
N_3	7.25	7.24	7.25	7.25	7.25
N_4	7.24	7.24	7.25	7.24	7.24
S. Em±	0.18	0.17	0.19	0.20	0.09
CD (P = 0.05)	NS	NS	NS	NS	NS
(Interaction) C x N					
S. Em±	0.36	0.34	0.39	0.41	0.18
CD (P = 0.05)	NS	NS	NS	NS	NS

Time of nutrient foliar spray 4th, 5th, and 6th DAS.

Table 6: Effect of crops and nutrient foliar spray on crude fat yield (g crude fat kg^{-1} of seed) under hydroponics

Treatments / Trials	First	Second	Third	Fourth	Pooled mean
Crops					
C_1	51.48	50.89	50.64	51.37	51.10
C_2	50.34	50.92	51.06	51.50	50.95
C_3	50.85	50.11	50.04	51.32	50.58
C_4	50.68	49.82	50.55	51.35	50.60
S. Em±	1.46	1.19	1.57	1.12	1.42
CD (P = 0.05)	NS	NS	NS	NS	NS
Nutrients					
N_0	48.25	47.46	47.05	48.07	47.71
N_1	56.50	56.13	56.86	57.34	56.71
N_2	52.08	52.01	52.34	53.45	52.47
N_3	48.89	48.86	48.22	49.26	48.81
N_4	48.47	47.70	48.41	48.81	48.35
S. Em±	1.64	1.33	1.76	1.25	1.58
CD (P = 0.05)	3.31	2.70	3.55	2.53	3.21
(Interaction) C x N					
S. Em±	3.28	2.67	3.52	2.50	3.17
CD (P = 0.05)	NS	NS	NS	NS	NS

Time of nutrient foliar spray 4th, 5th, and 6th DAS.

Crops			Nutrients		
C_1	-	Fodder maize	N_0	-	Control (without any spray)
C_2	-	Grain maize	N_1	-	19:19:19 @ 1%
C_3	-	Grain cowpea	N_2	-	DAP @ 0.5 % + KCL @ 0.5%
C_4	-	Horse gram	N_3	-	Panchagavya @ 3%
			N_4	-	Vermivash @ 1%

Table 7: Effect of crops and nutrient foliar spray on economics under hydroponics

Treatments	Cost of cultivation (Rs. per kg of seed)	Gross return (Rs. per kg of seed)	Net return (Rs. per kg of seed)	B:C ratio
C_1N_0	22.14	13.22	-8.92	0.60
C_1N_1	22.99	15.19	-7.80	0.66
C_1N_2	22.30	14.29	-8.01	0.64
C_1N_3	25.35	13.39	-11.96	0.53
C_1N_4	23.10	13.33	-9.77	0.58
C_2N_0	12.14	13.16	1.02	1.08
C_2N_1	12.99	15.04	2.05	1.16
C_2N_2	12.30	14.18	1.88	1.15
C_2N_3	15.35	13.29	-2.06	0.87
C_2N_4	13.10	13.42	0.32	1.02
C_3N_0	47.14	12.96	-34.18	0.27
C_3N_1	48.34	14.91	-33.43	0.31
C_3N_2	47.38	13.90	-33.48	0.29
C_3N_3	51.64	13.09	-38.55	0.25
C_3N_4	48.49	13.03	-35.47	0.27
C_4N_0	44.14	12.89	-31.25	0.29
C_4N_1	45.34	14.86	-30.48	0.33
C_4N_2	44.38	13.84	-30.54	0.31
C_4N_3	48.64	13.04	-35.60	0.27
C_4N_4	45.49	12.99	-32.50	0.29

Data not statistically analyzed

Crops			Nutrients		
C_1	-	Fodder maize	N_0	-	Control (without any spray)
C_2	-	Grain maize	N_1	-	19 : 19 : 19 NPK @ 1%
C_3	-	Grain cowpea	N_2	-	DAP 0.5% @ + KCL @ 0.5%
C_4	-	Horse gram	N_3	-	Panchagavya @ 3%
			N_4	-	Vermivash @ 1%

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