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Performance of Different Crops under Hydroponics Fodder Production System

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The experiment was conducted at New area Farm, Department of Forage crops, Tamil Nadu Agricultural University, Coimbatore, to evaluate the suitability of different crops for hydroponic fodder production. The crops includes fodder maize, grain maize, fodder bajra, grain bajra, barley, wheat, oat, fodder cowpea, grain cowpea, horse gram, soybean and lucerne. Among the different crops evaluated, fodder maize, grain maize, grain cowpea and horse gram were found to be suitable for hydroponics fodder production and recorded higher shoot length, root length, green fodder yield, dry matter yield, crude fibre content, and crude fibre yield. These crops were followed by fodder cowpea.

Key words: Hydroponics, Shoot length, Root length, Green fodder, Dry matter, Crude fibre.

Agriculture in India is a fiscal symbiosis of crop and livestock production with cattle as the base. Livestock sector plays an imperative role in the rural economy of India by providing employment and additional family income along with its ability to supply nutritious diet through milk, meat and egg to the millions of people. Livestock sector contributes about 25.6 per cent of the total agricultural income and 4.11 per cent of the National GDP (Livestock Census, 2012). Though India has made greater stride in livestock population, the productivity of milk and other livestock products are very low when compared to other countries around the world. Chronic dearth of feeds and forages together with its deprived quality ascribed the lower productive capacity and fertility of Indian livestock (Brithal and Jha, 2005). As the gap between the demand and supply of the green fodder for livestock becoming unconquerable, researchers and farmers are in search for an alternative fodder or fodder production method, that would restore fodder and livestock production. In this juncture, hydroponics is the state of the art technology that has revolutionized the green fodder production in the 21st century (Tudor *et al.,* 2003). Hydroponics is a method of growing green fodder without soil in an environmentally controlled houses or machines. It is a well-known technique for year round fodder production with least water consumption. Keeping the above points in view, the present study was mooted with evaluation of suitable crops for fodder production and assessment of quality of green fodder produced through hydroponics.

Material 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 laid out in completely randomized design comprised three replications and twelve crops as treatments *viz*., fodder maize, grain maize, fodder bajra, grain bajra, barley, wheat, oat, fodder cowpea, grain cowpea, horse gram, soybean and lucerne and the experiment was repeated 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 shoot and root length were taken on 2nd, 4th, 6th, and 8th day of seeding of crops, respectively. The green fodder yield, dry matter yield were recorded after the harvest of the crops. Quality parameter such as crude fibre content analyzed as per the method suggested Goering and Vansoest (1970) and crude fibre yield were calculated on dry weight basis. 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). Pooled and individual trial wise data for the parameters *viz.,* green fodder yield, dry matter yield, crude fibre content, crude fibre yield, are detaily furnished. While, pooled data for the parameters viz., shoot length, root length, are given.

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Results and Discussion

Shoot length

The results revealed (Table. 1) that significantly higher shoot length was recorded in fodder maize (3.17, 10.08, 19.76 and 25.12 cm) at different stages (2nd, 4th, 6th, and 8th day) of observation, respectively. It was on par with grain maize (3.12, 9.80, 19.22 and 24.87 cm), grain cowpea (3.10, 9.84, 19.29 and 24.84 cm) and horse gram (3.08, 9.73, 19.11 and 24.77 cm) at different stages (2nd, 4th, 6th, and 8th day) of observation. However, significantly lower shoot length was observed in soybean (1.08, 3.98, 7.66 and 0.00 cm) and lucerne (1.01, 3.79, 0.00 and 0.00 cm) at different stages (2nd, 4th, 6th, and 8th day) of observation, respectively. The variation in shoot length of different crops under hydroponics has been reported Mooney (2005).

Table 1. Effect of different crops on shoot and root length (cm) under hydroponics

Treatments / Days	Shoot length				Root length			
	2nd	4th	6th	8th	2nd	4th	6th	8th
C_1 – Fodder maize	3.17	10.08	19.76	25.12	1.76	6.86	17.24	22.71
			(1.31)	(1.42)			(1.26)	(1.37)
C_2 – Grain maize	3.12	9.80	19.22	24.87	1.73	6.84	17.23	22.69
			(1.30)	(1.41)			(1.26)	(1.37)
C_3 – Fodder bajra	1.85	5.38	10.66	14.80	0.72	4.12	7.64	12.36
			(1.07)	(1.20)			(0.93)	(1.13)
C_4 – Grain bajra	1.82	5.30	10.53	14.70	0.71	4.09	7.61	12.32
			(1.06)	(1.20)			(0.93)	(1.12)
C_5 – Barley	2.23	6.98	14.48	18.43	0.96	5.02	13.01	15.72
			(1.19)	(1.29)			(1.14)	(1.22)
C_6 – Wheat	2.21	6.93	14.41	18.40	0.94	5.00	12.99	15.70
			(1.19)	(1.29)			(1.14)	(1.22)
C_7 – Oat	2.20	6.91	14.38	18.36	0.93	4.98	13.04	15.67
			(1.19)	(1.29)			(1.15)	(1.22)
C_8 – Fodder cowpea	2.68	8.33	16.70	21.65	1.31	5.81	14.92	18.57
			(1.25)	(1.34)			(1.20)	(1.29)
C_9 – Grain cowpea	3.10	9.84	19.29	24.84	1.72	6.82	17.29	22.67
			(1.30)	(1.41)			(1.26)	(1.37)
C_{10} – Horse gram	3.08	9.73	19.11	24.77	1.71	6.80	17.19	22.63
			(1.30)	(1.41)			(1.26)	(1.37)
C_{11} – Soybean	1.08	3.98	7.66	0.00	0.51	2.93	5.79	0.00
			(0.93)	(0.00)			(0.83)	(0.00)
C_{12} – Lucerne	1.01	3.79	0.00	0.00	0.49	2.90	0.00	0.00
			(0.00)	(0.00)			(0.00)	(0.00)
SEd	0.05	0.19	0.01	0.01	0.15	0.13	0.008	0.01
CD (P=0.05)	0.11	0.40	0.02	0.02	0.32	0.28	0.017	0.02

Figures in parenthesis are log transformed

Root length

At all the different stages observation conspicuously higher root length was recorded in fodder maize (1.76, 6.86, 17.24 and 22.71 cm) at different stages (2nd, 4th, 6th, and 8th day) of observation, respectively (Table. 1). It was on par with grain maize (1.73, 6.84, 17.23 and 22.69 cm), grain cowpea (1.72, 6.82, 17.29 and 22.67 cm) and horse gram (1.71, 6.80, 17.19 and 22.63 cm) at different stages (2nd, 4th, 6th, and 8th day) of observation. All these four crops were on par with each other. However, significantly lower root length was observed in soybean (0.51, 2.93, 5.79 and 0.00 cm) and lucerne (0.49, 2.90, 0.00, and 0.00 cm) at different stages (2nd, 4th, 6th, and 8th day) of observation, respectively. The results are in confirmation with the findings of Rao and Ito, 1998; Dukare *et al*. (2017).

Green fodder yield

Fodder maize registered significantly higher green fodder yield of 5.37, 5.45, 5.41 and 5.67 kg GFY kg^{-1} of seed on first, second, third and fourth trial, respectively (Table. 2 & Fig. 1). It was on par with grain maize (5.26, 5.31, 5.28 and 5.53 kg GFY kg^{-1} of seed), grain cowpea (5.21, 5.29, 5.18, and 5.48 kg GFY kg^{-1} of seed) and horse gram (5.16, 5.21, 5.16, and 5.44 kg GFY kg^{-1} of seed) on first, second, third and fourth trial, respectively. However, soybean and lucerne, registered the nil green fodder yield in all the four trials.

Table 2. Effect of different crops on green fodder yield (kg GFY kg^{-1} of seed) and dry matter yield (g DMY kg^{-1} of seeds) under hydroponics

Treatments / Trial	Green fodder yield					Dry matter yield				
	First	Second	Third	Fourth	Pooled mean	First	Second	Third	Fourth	Pooled mean
C_1 – Fodder maize	5.37	5.45	5.41	5.67	5.48	690.04	745.56	685.99	761.48	720.77
	(0.80)	(0.81)	(0.81)	(0.82)	(0.81)	(2.84)	(2.87)	(2.84)	(2.88)	(2.86)
C_2 – Grain maize	5.26	5.31	5.28	5.53	5.37	677.48	727.47	670.56	744.34	704.96
	(0.80)	(0.80)	(0.80)	(0.81)	(0.80)	(2.83)	(2.86)	(2.83)	(2.87)	(2.85)
C_3 – Fodder bajra	2.56	2.75	2.72	2.88	2.73	276.22	305.53	300.29	336.38	304.61
	(0.55)	(0.57)	(0.57)	(0.59)	(0.57)	(2.44)	(2.49)	(2.48)	(2.53)	(2.49)
C_4 – Grain bajra	2.49	2.71	2.70	2.85	2.69	268.17	302.17	297.54	332.31	300.05
	(0.54)	(0.57)	(0.57)	(0.59)	(0.57)	(2.43)	(2.48)	(2.48)	(2.52)	(2.48)
C_5 – Barley	3.08	3.12	3.11	3.46	3.19	358.82	368.47	363.56	437.34	382.05
	(0.61)	(0.61)	(0.61)	(0.65)	(0.62)	(2.56)	(2.57)	(2.56)	(2.64)	(2.58)
C_6 – Wheat	3.05	3.06	3.08	3.38	3.14	340.68	363.22	361.28	425.54	372.68
	(0.61)	(0.61)	(0.61)	(0.64)	(0.62)	(2.53)	(2.56)	(2.56)	(2.63)	(2.57)
C_7 – Oat	3.02	3.05	3.05	3.35	3.12	333.40	362.65	358.38	421.10	368.88
	(0.60)	(0.61)	(0.61)	(0.64)	(0.61)	(2.52)	(2.56)	(2.56)	(2.63)	(2.57)
C_8 – Fodder cowpea	4.12	4.22	4.17	4.29	4.20	501.81	508.93	459.53	538.82	502.28
	(0.71)	(0.72)	(0.71)	(0.72)	(0.72)	(2.70)	(2.71)	(2.66)	(2.73)	(2.70)
C_9 – Grain cowpea	5.21	5.29	5.18	5.48	5.29	678.86	696.16	645.43	749.66	692.53
	(0.79)	(0.80)	(0.79)	(0.81)	(0.80)	(2.83)	(2.84)	(2.81)	(2.88)	(2.84)
C_{10} – Horse gram	5.16	5.21	5.16	5.44	5.24	673.38	692.93	647.06	745.82	689.80
	(0.79)	(0.79)	(0.79)	(0.81)	(0.80)	(2.83)	(2.84)	(2.81)	(2.87)	(2.84)
C_{11} – Soybean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
C_{12} – Lucerne	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
SEd	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.01	0.01
CD (P=0.05)	0.04	0.03	0.02	0.03	0.03	0.05	0.02	0.05	0.03	0.02

Figures in parenthesis are log transformed

GFY – Green fodder yield, DMY – Dry matter yield

Pooled analysis also showed that, fodder maize produced maximum green fodder yield of 5.48 kg GFY kg^{-1} of seed. It was on par with grain maize (5.37 kg GFY kg^{-1} of seed), grain cowpea (5.29 kg GFY kg^{-1} of seed) and horse gram (5.24 kg GFY kg^{-1} of seed). However, among all the crops, lucerne and soybean, registered the nil green fodder yield. These findings are in line with the results by Sneath and Mcintosh (2003), (Naik et al., 2013), (Reddy, 2014) and (Kamanga, 2016).

Dry matter yield

There was an appreciable difference in dry matter yield due to different crops under hydroponic system (Table. 2). Among all the crops studied, significantly higher dry matter yield was recorded in fodder maize with 690.04, 745.56, 685.99 and 761.48 g DMY kg^{-1} of seed on first, second, third and fourth trial, respectively. It was on par with and grain maize (677.48, 727.47, 670.56 and 744.34 g DMY kg^{-1} of seed), grain cowpea (678.86, 696.16, 645.43, and 749.66 g DMY kg^{-1} of seed) and horse gram (673.38, 692.93, 647.06, and 745.82 g DMY kg^{-1} of seed) on first, second, third and fourth trial, respectively. However, among all the crops, lucerne and soybean, registered the nil green fodder yield in all four trials.

Pooled analysis of dry matter yield of all the four trials also showed that fodder maize recorded significantly higher dry matter yield of 720.77 g DMY kg^{-1} of seed. It was on par with grain maize, grain cowpea, and horse gram which registered the dry matter of 704.96, 692.53 and 689.89 g DMY kg^{-1} of seed, respectively. However, among all the crops, lucerne and soybean, registered the nil dry matter yield. This is in agreement with findings of Sneath and Mcintosh (2003) and Naik *et al.* (2016).

Quality parameter

Crude fibre content

Significant variations were expressed by different crops used under the study on crude fibre content (Table. 4). The fodder maize recorded with highest crude fibre content of 7.21, 7.25, 7.23 and 7.23 per cent during first, second, third and fourth trial periods respectively. It was on par with grain maize (7.16,

Table 3. Effect of different crops on crude fibre content (per cent) (g CFY kg^{-1} of seeds) under hydroponics

Treatments / Trial	Crude fibre content				
	First	Second	Third	Fourth	Pooled mean
C_1 – Fodder maize	7.21	7.25	7.23	7.23	7.23
	(15.58)	(15.62)	(15.60)	(15.58)	(15.60)
C_2 – Grain maize	7.16	7.18	7.17	7.17	7.17
	(15.52)	(15.54)	(15.53)	(15.53)	(15.53)
C_3 – Fodder bajra	4.63	4.56	4.60	4.60	4.60
	(12.42)	(12.33)	(12.38)	(12.38)	(12.38)
C_4 – Grain bajra	4.25	4.24	4.25	4.25	4.25
	(11.89)	(11.87)	(11.89)	(11.88)	(11.88)
C_5 – Barley	6.16	6.18	6.17	6.17	6.17
	(14.37)	(14.37)	(14.38)	(14.38)	(14.38)
C_6 – Wheat	6.12	6.11	6.12	6.12	6.12
	(14.30)	(14.30)	(14.31)	(14.31)	(14.32)
C_7 – Oat	6.09	6.06	6.08	6.08	6.08
	(14.29)	(14.25)	(14.25)	(14.27)	(14.27)
C_8 – Fodder cowpea	6.85	6.98	6.92	6.92	6.92
	(15.16)	(15.29)	(15.24)	(15.23)	(15.24)
C_9 – Grain cowpea	7.13	7.18	7.16	7.16	7.16
	(15.48)	(15.54)	(15.52)	(15.51)	(15.52)
C_{10} – Horse gram	7.15	7.20	7.18	7.20	7.18
	(15.51)	(15.56)	(15.53)	(15.56)	(15.54)
C_{11} – Soybean	0.00	0.00	0.00	0.00	0.00
	(0.48)	(0.48)	(0.48)	(0.48)	(0.48)
C_{12} – Lucerne	0.00	0.00	0.00	0.00	0.00
	(0.48)	(0.48)	(0.48)	(0.48)	(0.48)
SEd	0.35	0.42	0.27	0.39	0.20
CD (P=0.05)	0.73	0.88	0.56	0.82	0.42

Figures in parenthesis are Arcsine transformed

7.18, 7.17 and 7.17 per cent during first, second, third and fourth trial, respectively), horse gram (7.15, 7.20, 7.18 and 7.20 per cent on first, second, third and fourth trial, respectively), fodder cowpea (6.85, 6.98, 6.92 and 6.92 per cent on first, second, third and fourth trial, respectively), and grain cowpea (7.13,

Table 4. Effect of different crops on and crude fibre yield under hydroponics

Treatments / Trial	Crude fibre yield				
	First	Second	Third	Fourth	Pooled mean
C_1 – Fodder maize	49.75	54.05	49.60	55.06	52.11
	(1.71)	(1.74)	(1.70)	(1.75)	(1.73)
C_2 – Grain maize	48.51	52.23	48.08	53.37	50.55
	(1.69)	(1.73)	(1.69)	(1.74)	(1.71)
C_3 – Fodder bajra	12.79	13.93	13.80	15.46	13.99
	(1.14)	(1.17)	(1.17)	(1.22)	(1.18)
C_4 – Grain bajra	11.40	12.81	12.63	14.11	12.74
	(1.09)	(1.14)	(1.13)	(1.18)	(1.14)
C_5 – Barley	22.10	22.77	22.43	26.98	23.57
	(1.36)	(1.38)	(1.37)	(1.45)	(1.39)
C_6 – Wheat	20.85	22.19	22.09	26.02	22.79
	(1.34)	(1.37)	(1.36)	(1.43)	(1.38)
C_7 – Oat	20.30	21.98	21.77	25.58	22.41
	(1.33)	(1.36)	(1.36)	(1.42)	(1.37)
C_8 – Fodder cowpea	34.37	35.52	31.78	37.26	34.73
	(1.55)	(1.56)	(1.52)	(1.58)	(1.55)
C_9 – Grain cowpea	48.40	49.98	46.18	53.64	49.55
	(1.69)	(1.71)	(1.67)	(1.74)	(1.70)
C_{10} – Horse gram	48.15	49.89	46.43	53.70	49.54
	(1.69)	(1.71)	(1.68)	(1.74)	(1.70)
C_{11} – Soybean	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
C_{12} – Lucerne	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
SEd	0.02	0.02	0.02	0.02	0.01
CD (P=0.05)	0.04	0.04	0.04	0.04	0.02

Figures in parenthesis are to log transformed

7.18, 7.16, and 7.16 per cent on first, second, third and fourth trial, respectively) whereas, soybean and lucerne registered the nil crude fibre content in all the four trials.

Pooled analysis also showed the highest crude fibre content of 7.23 per cent in fodder maize. It was on par with crude fibre content of 7.18 per cent in fodder cowpea, 7.17 per cent in grain maize, 7.16 per cent in grain cowpea and 6.92 per cent in horse gram. Similar views have also been expressed by Naik et al. (2013).

Table 5. Effect of different crops on economics under hydroponics

Treatments	Cost of cultivation (Rs. kg^{-1} of seed)	Gross return (Rs. kg^{-1} of seed)	Net return (Rs. kg^{-1} of seed)	B:C ratio
C_1 - Fodder maize	22.14	13.69	-8.45	0.62
C_2 - Grain maize	12.14	13.36	1.22	1.10
C_3 - Fodder bajra	37.14	6.82	-30.32	0.18
C_4 - Grain bajra	32.14	6.72	-25.42	0.21
C_5 - Barley	42.14	7.98	-34.16	0.19
C_6 - Wheat	40.14	7.86	-32.28	0.20
C_7 - Oat	52.14	7.79	-44.35	0.15
C_8 - Fodder cowpea	72.14	10.50	-61.64	0.15
C_9 - Grain cowpea	47.14	13.23	-33.92	0.28
C_{10} - Horse gram	44.14	13.11	-31.03	0.30
C_{11} - Soybean	82.14	0.00	-82.14	0.00
C_{12} - Lucerne	702.14	0.00	-702.14	0.00

Data not statistically analyzed

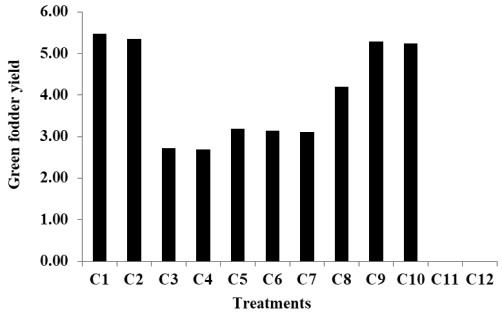

Fig. 1. Effect of different crops on green fodder yield under hydroponics

Crude fibre yield

The crude fibre yield was calculated and furnished in table 4 and fig 2 and it was considerably varied with different crops. Among all the crops, maximum crude fibre yield was registered in fodder maize with 49.75, 54.05, 49.60 and 55.06 g CFY kg^{-1} of seeds during first, second, third and fourth trial, respectively. It was on par with grain maize (48.51, 52.23, 48.08 and 53.37 g CFY kg^{-1} of seeds during first, second, third and fourth trial, respectively), grain cowpea (48.40, 49.98, 46.18 and 53.64 g CFY kg^{-1} of seeds during first, second, third and fourth trial, respectively) and horse gram (48.15, 49.89, 46.43 and 53.70 g CFY kg^{-1} of seeds during first, second, third and fourth trial, respectively). However, soybean and lucerne registered the nil crude fibre yields in all the four trials.

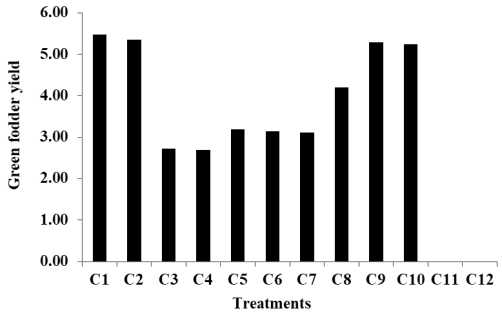

Fig. 2. Effect of different crops on crude fat yield under hydroponics

Pooled analysis of crude fibre yield also showed the similar results as obtained from individual trials. Maximum crude fibre yield of 52.11 g CFY kg^{-1} of seeds was recorded in fodder maize. It was on par with grain maize, grain cowpea and horse gram which recorded the crude fibre yield of 50.55, 49.55 and 49.54 g CFY kg^{-1} of seeds, respectively. These findings are in line with the results by Thadchanamoorthy and Pramalal (2012)

Economics

The results (Table 5) of the investigation clearly indicated that among the crops tested under hydroponic fodder production system, grain maize registered high net return of Rs. 1.22 kg^{-1} of seed and benefit cost ratio of 1.10 was found to be more suitable crop for economical green fodder production through hydroponics. The cost effectiveness of grain maize to produce green fodder under hydroponics was reported by Naik *et al.* (2015).

Conclusion

Based on the findings of this experiment, fodder maize, grain maize, grain cowpea and horse gram were identified as best performing crops under hydroponics for getting higher green fodder yield and nutritive value with relatively lesser cost.

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