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Biomass yield and water productivity of different hydroponic fodder crops

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Abstract
Biomass yield and water productivity of different hydroponic crops
In these experiment, we aim to find out the biomass yield, physical water productivity and economic water productivity of the six crops taken *viz.* pearl millet (*Pennisetum perpareum*), yellow maize (*Zea mays*), Oat (*Avena sativa*), Barley *(Hordeum vulgare*), wheat (*Triticum aestivum*) and white maize (*Zea mays*) which were grown hydroponically to produce fodder. The research was conducted in the April-May, 2016 in PGI farm of Mahatma Phule Krishi Vidyapeeth, Rahuri. For the study a rack of 2.7 m x 1.5 m area was used made of UV-PVC polypipe with a capacity of holding 54 trays of size 50 cm x 30 cm x 5 cm. factorial complete randomized design were the experimental design used. Foliar spray was done on 5th day to all the crops taking two different water soluble fertilizers urea @ 0.5 % and 19-19-19 @ 0.5 % and one was kept as control (no foliar spray) in each crop. So, all together the treatment combinations were eighteen. Water to the system was supplied by micro sprinkler/ jet irrigation applied at every regular intervals of 3 hours in all crops except pearl millet which needed only once in 4 hours. Superior result of biomass yield was recorded in yellow maize, white maize and wheat with foliar application of 19-19-19 WSF. The green biomass was maximum up to 8days later on reduction in green biomass at 9th and 10th day. The biomass was increased 3-6 folds according to crop in a growing period of 10 days. However, in both physical and economic water productivity, pearl millet 19-19-19 @ 0.5 % foliar spray was highest followed by urea @ 0.5 % treated pearlmillet. Results showed the potential water productivity of pearl millet.

Keywords: Biomass yield, physical water productivity, economic water productivity, hydroponic fodder crop, UV-PVC polypipe, water soluble fertilizers, micro-sprinkler irrigation.

Introduction
Livestock production requires a good fodder supply for better production. But there is a lean supply during summer season. So, there needs to be an alternative like the hydroponic fodder production. At present, researches had been undergoing in ICAR old Goa complex mainly on maize. In other countries study related to feeding of barley hydroponic fodder to livestock had been conducted but there had been limited research in improving the productivity of the fodder itself. The interval between water application was usually 2 hr in farmers field. Calder, B., (2002) [2] reported that the hydroponic system requires a fraction of the water usage of conventional farming while still supplying high quality stock feed. It takes between 1 to 2 litres of water to produce one kg of fodder as compared with 80 – 90 litres of water to grow a kg of green grass. High water use efficiency is, however, a major advantage of this technique which saves about 95-97 % of used water in comparison to conventional agriculture with small piece of land. The hydroponics forage production requires only about 3-5 % of water needed to produce same amount of forage produced under field condition (Al- Karaki *et al.,* 2012) [1]. Sneath and Mclntosh (2003) [6] noted that absorption of nitrates facilitates the metabolism of nitrogenous compounds from carbohydrate reserves thus increasing CP level. Naik *et al.*, (2011) [4] reported that one tray containing 1.5kg maize seeds produces 7-9kg green fodder with fodder height of 20-25cm. So, in order to improve yield and also the water productivity the following research had been conducted.

Materials and method
Soaking of seeds and the rapid uptake of water for facilitating the metabolism and utilization of reserve materials of the seeds for growth and development of the plant is very important step for the production of hydroponic forage. Number of hours of soaking for all crops was 6hr. The water was then drained and the seeds packed or wrap in wet gunny bags and kept for few more hours. It varies with different crop. Pearl millet and wheat was kept wrapped in gunny bag for 7hr.

In yellow maize and white maize it was kept for 14 hours while in oat and barley for 6hr.Water was sprinkled in the gunny bags from time to time making sure it is always kept wet. The germinated seeds were then transferred in the trays. The seed rate were fixed. The seeds were filled in the trays to the level of the ridges and were soaked separately for each tray. When the absorbed water and bulged out they a slightly above the ridges and become the perfect seed layer for growth. When the seeds were too low they do not grow well and when there were too much seed they began to show root rotting symptoms, mould growth etc. before reaching the targeted harvesting day.

The seeds were kept in the tray and water was sprinkled on tray at an interval of 3hr till the third day. And from 4th day onwards water was supplied at an interval of 2 hr during day time (1min irrigation after every 2hr) and after 6 PM till early morning 6AM, water was sprinkled on tray at an interval of 4hr. On the 5th day from early morning the automatic system was switch off. Water mixed with urea @ 0.5% was foliar sprayed with the help of hand sprayer and water mixed with 19-19-19 starter grade of water soluble fertilizer @ 0.5% was sprayed. As control three trays of each crop was sprayed with tap water only. Water or the mixer was foliar sprayed at every 3 hr interval 3 times and after the last spray automatic system of irrigation was activated again. In treatment, Factor A was the hydroponic crops in which C_1- Pearl millet, C_2- Maize, C_3- Oat, C_4- Barley, C_5- Wheat and C_6 - White maize while Factor B were foliar spray of water soluble fertilizers viz. F_1- No foliar application, F_2 - Foliar spray of N-Urea 0.5% spray and F_3 - Foliar spray of NPK-19:19:19 WSF spray at 0.5%. The biomass of the treatments were weighed from 8th day onwards till day of harvest i.e. 10th day using a weighing machine.

To find the physical water productivity, the yield of fodder per tray and the water used per tray was taken into consideration while for economic water productivity economic return per tray and water requirement per tray was taken into consideration. It is calculated by using the following formula:

$$\text{Physical Water Productivity} = \frac{\text{Biomass yield per tray (kg)}}{\text{Water requirement (lit)}}$$

$$\text{Economic Water Productivity} = \frac{\text{Net return per tray (□)}}{\text{Water requirement per tray (lit)}}$$

Results and discussion

Biomass Yields

The periodical biomass yield was recorded at 8th , 9th and 10th day and it was observed that the maximum biomass yield was obtained from different hydroponically grown crop was at 8th day later on there was reduction in biomass yield. At 8th among the different hydroponically grown crop maximum yield per tray was obtained in yellow maize followed by wheat crop.

In all the crops taken treatment influence of foliar spray was observed. Maximum yield was shown in 19-19-19 WSF @ 0.5 % sprayed treatments followed by treatments with urea @ 0.5 % applied.

Yellow maize and white had maximum yield with an increase of 6 folds from its initial seed taken. But higher yield was observed in yellow maize compared to white maize. Among the foliar spray treatment in both the crops, 19-19-19 WSF @ 0.5 % produced better result than urea @ 0.5 % treated yellow maize and white maize.

It was in conformity with reports of Naik *et al* (2013) [5] where the increase in weight of the hydroponic maize fodder than the seed weight on fresh basis was 5.5 folds.

Dung *et al*. (2010) [3] also estimated that fresh sprouts weighed about 1.75 times their original pre-steeped weight after 1day, 2.0 times after 2 days, 2.3 times after 3 days, 2.7 times after 4 days, 3.3 times after 5 days, 3.6 times after 6 days and 3.7 times after 7 days.

The best treatment combination among all on 10th day was 19-19- WSF @ 0.5 % treated yellow maize (6.92 kg tray^{-1}) followed by 19-19-19 WSF @ 0.5 % treated white maize. Meanwhile the least yield was observed in control of barley and for among foliar sprayed treatments urea @ 0.5 % sprayed oat.

The mould growth increased on 9th and 10th day and some rotting and drying up of roots was seen in some cases. These could be reason for its reduction in yield after 8th day. If we consider only yield then the fodder should be harvested on 8thday rather on farmers practiced duration of 9th and 10th days and even more. At the same time the fodder was fresher on 8th day, with negligible mould growth and browning of leaves.

Table

Treatment combination		Seed (kg) tray^{-1}	Biomass yield (kg tray^{-1})				
			8th day	9th day	% reduced	10th day	% reduced
C_1F_1:	Pearlmillet + Control	0.7	4.69	4.64	1.1	4.59	2.0
C_1F_2 :	Pearlmillet + Urea foliar spray @ 0.5 %	0.7	5.06	5.01	0.9	4.97	1.7
C_1F_3 :	Pearlmillet + 19-19-19 WSF spray @ 0.5 %	0.7	5.55	5.53	0.3	5.51	0.7
C_2F_1 :	Yellow Maize + Control	1.1	5.34	5.30	0.7	5.24	1.8
C_2F_2 :	Yellow Maize + Urea foliar spray @ 0.5 %	1.1	6.43	6.40	0.4	6.39	0.6
C_2F_3:	Yellow Maize + 19-19-19 WSF spray @ 0.5 %	1.1	6.96	6.94	0.2	6.92	0.5
C_3F_1 :	Oat + Control	0.6	2.82	2.81	0.3	2.76	2.1
C_3F_2:	Oat + Urea foliar spray @ 0.5 %	0.6	3.23	3.22	0.3	3.18	1.5
C_3F_3 :	Oat + 19-19-19 WSF spray @ 0.5 %	0.6	3.84	3.80	1.0	3.77	1.8
C_4F_1 :	Barley + Control	0.6	2.79	2.74	1.7	2.71	2.8
C_4F_2 :	Barley + Urea foliar spray @ 0.5 %	0.6	3.42	3.40	0.5	3.34	2.3
C_4F_3 :	Barley +19-19-19 WSF spray @ 0.5 %	0.6	3.60	3.57	0.8	3.52	2.2
C_5F_1 :	Wheat + Control	0.8	5.41	5.16	4.6	5.12	5.3
C_5F_2 :	Wheat + Urea foliar spray @ 0.5 %	0.8	5.53	5.50	0.5	5.43	1.8
C_5F_3 :	Wheat + 19-19-19 WSF spray @ 0.5 %	0.8	5.62	5.59	0.5	5.51	1.9
C_6F_1:	White Maize + Control	1.2	5.28	5.37	-	5.11	3.2
C_6F_2 :	White Maize + Urea foliar spray @ 0.5 %	1.2	6.29	6.47	-	6.14	2.3
C_6F_3 :	White Maize + 19-19-19 WSF spray @ 0.5 %	1.2	6.85	6.82	0.4	6.74	1.6
	S.Em. ±		0.03	0.02		0.02	
	CD at 5%		0.10	0.06		0.06	
	Mean		5.01	4.95		4.84	

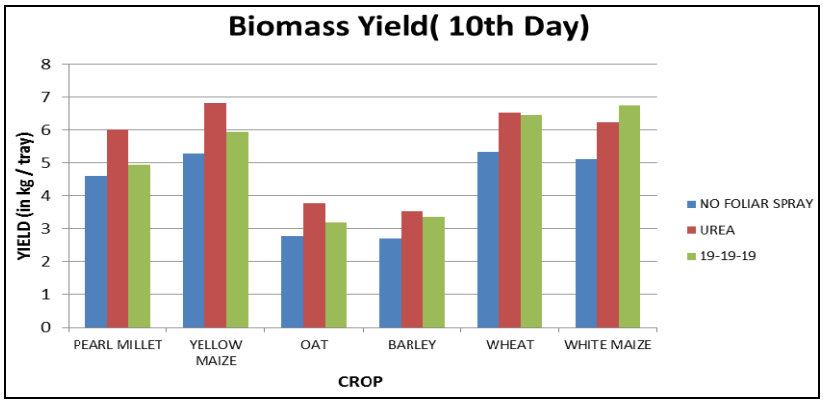

Fig 1: Green fodder yield in different treatment combination on 10th day

Water productivity

Among the different hydroponic crops the maximum physical water productivity was noticed in pearl millet with foliar application of 19-19-19 water soluble fertilizers @ 0.5 % (0.272 kg lit^{-1}) followed by yellow maize (0.242 Kg lit^{-1}). The lowest water productivity was noticed in the treatment oat with no foliar application (0.098 Kg lit^{-1}). The water requirement of pearl millet was low compared with other crops taken with an average yield, so the physical productivity was high in pearl millet and the results of the three foliar treatments varied because of their slight yield difference.

The economic water productivity of 10th day among the different hydroponic crops was noticed in pearl millet with foliar application of 19-19-19 water soluble fertilizers @ 0.5 % (20.73 □ lit^{-1}) followed by yellow maize (20.19 □ lit^{-1}). The lowest water productivity was noticed in the treatment barley with no foliar application (4.48 □ lit^{-1})

Table 2: Periodical water productivity as influenced by different treatments on 10th day

Treatment		Physical water productivity (kg lit^{-1})	Economic Water productivity value (□ lit^{-1}) per tray
C_1F_1:	Pearlmillet + Control	16.63	0.221
C_1F_2 :	Pearlmillet + Urea foliar spray @ 0.5 %	18.84	0.243
C_1F_3 :	Pearlmillet + 19-19-19 WSF spray @ 0.5 %	20.73	0.270
C_2F_1 :	Yellow Maize + Control	16.03	0.182
C_2F_2 :	Yellow Maize + Urea foliar spray @ 0.5 %	17.53	0.222
C_2F_3 :	Yellow Maize + 19-19-19 WSF spray @ 0.5 %	20.19	0.240
C_3F_1 :	Oat + Control	4.71	0.086
C_3F_2:	Oat + Urea foliar spray @ 0.5 %	6.54	0.110
C_3F_3 :	Oat + 19-19-19 WSF spray @ 0.5 %	9.07	0.130
C_4F_1 :	Barley + Control	4.48	0.094
C_4F_2 :	Barley + Urea foliar spray @ 0.5 %	7.25	0.114
C_4F_3 :	Barley +19-19-19 WSF spray @ 0.5 %	7.97	0.122
C_5F_1 :	Wheat + Control	14.11	0.177
C_5F_2 :	Wheat + Urea foliar spray @ 0.5 %	14.65	0.188
C_5F_3 :	Wheat + 19-19-19 WSF spray @ 0.5 %	14.79	0.191
C_6F_1:	White Maize + Control	13.15	0.177
C_6F_2 :	White Maize + Urea foliar spray @ 0.5 %	16.13	0.213
C_6F_3 :	White Maize + 19-19-19 WSF spray @ 0.5 %	18.70	0.234
	S. Em. ±	0.02	0.011
	CD at 5%	0.07	0.010
	Mean	10.75	0.178

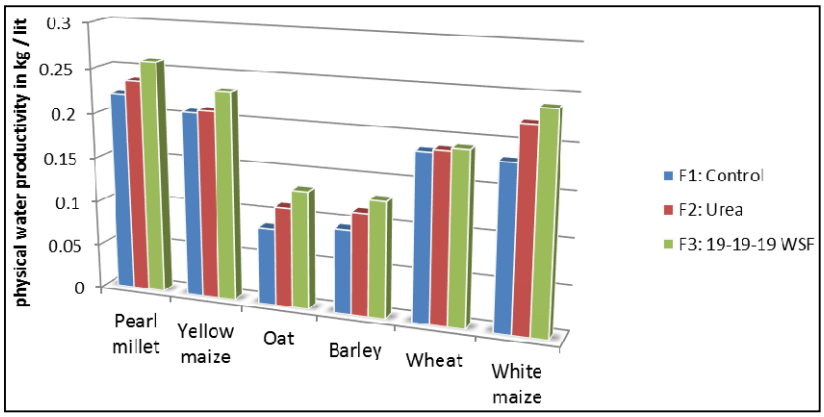

Fig 2: Physical water productivity as influenced due to foliar application in different hydroponic crops

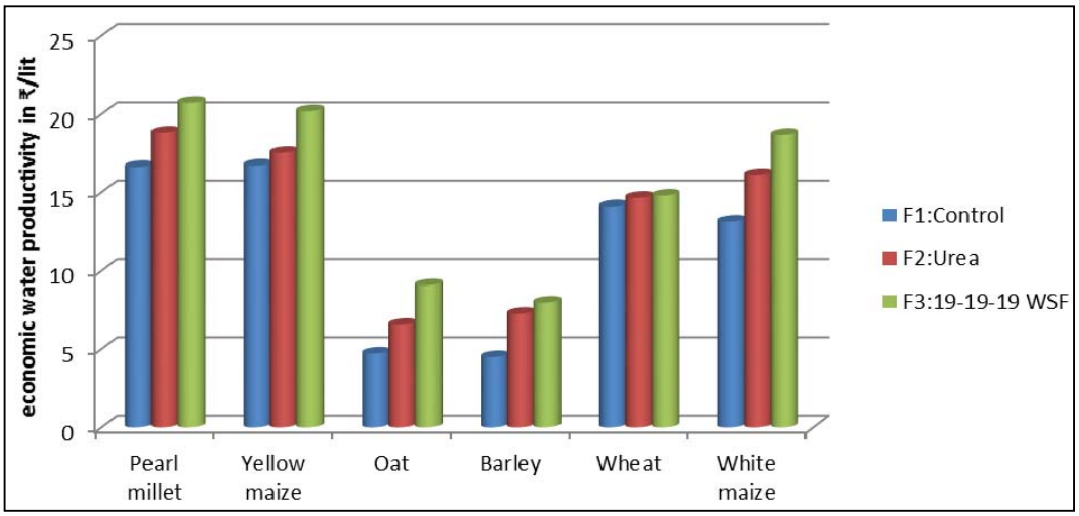

Fig 3: Economic water productivity as influenced due to foliar application in different hydroponic crops

Conclusions

Considering mainly biomass yield, the crop with maximum yield was yellow maize followed by white maize. But if we consider from quality point of view pearl millet was also suitable for Indian condition. Influence of foliar spray clearly. Effect of 19-19-19 WSF @ 0.5 % was more than foliar spray treatment in different.

19-19-19 WSF @ 0.5 % foliar spray treatment on yellow maize crop had highest biomass yield followed by 19-19-19 foliar spray treatment @ 0.5 % on white maize. The biomass yield of wheat with 19-19-19 WSF @ 0.5 % foliar spray treatment combination, wheat with Urea @ 0.5 % foliar spray treatment combination and pearl millet with 19-19-19 WSF @ 0.5 % foliar spray treatment combination were in par with each other. There was 3-6 folds increase in yield in all the crops in spite of growing in uncontrolled environment.

water productivity both physical and economic was highest in pearlmillet where water requirement was minimum.

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