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Productivity and profitability of different crops under the fertigated hydroponic condition

Tessema Tesfaye Atumo *, Milkias Fanta Heliso and Derrebe Kassa Hibebo

Southern Agricultural Research Institute, Arba Minch Agricultural Research Center, Feed and Nutrition Program, P.O. Box 2228, Arba Minch, Ethiopia.

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Abstract

Fodder production competition increased due to ever-increasing human pressure on land for the production of food crops and hydroponic fodder production could be the one option to commit the problem. Five crops (maize, oats, cowpea, lablab, and common bean) seeds with and without fertigation evaluated for fodder yield laid out in a completely randomized design with three replications at Arba Minch Agricultural Research Center during May-August 2019. Shoot length, seed sprouting ability, and duration, green fodder yield were measured. Cereal grains took longer days to be sprouted than pulses. Pulses especially common beans weighed others in the experiment. All crops in the experiment were found to be suitable for hydroponic fodder production. Partial budget analysis showed that hydroponic fodder production could benefit by 30.8% more than grain production. Hydroponic fodder production could be the option for city agriculture, especially in the smallholder poultry business for young entrepreneurs, less land holding farmers, elders and women, and even other interested groups in urban agriculture. Thus, it is ideal for small business groups and the nutritional aspect may be considered by animal nutritionists further.

Keywords: Fertigation; Green Forage; Hydroponic; Partial Budget Analysis

1. Introduction

Green fodder is essential to feed livestock but the reduced availability of land and lack of water making difficult to produce required quantity green fodder throughout the year. The lack of quality fodder hampers the growth; production and reproduction of livestock. Hydroponic fodder is a good option in front of the farmer because it grows fast; it contains a high nutrient value; and the most important thing is animals like to eat [1]. The methods and use of hydroponic fodder production was since 1800s [2]. Any sort of shelter; garage; basement; room; low density plastic sheets; greenhouse; poly-hut with solid floor of compacted earth; concrete; cobblestone and other material [3]; where the temperature; humidity and light can be controlled are used for hydroponic fodder production [4]. Fodder production competition increased due to ever increasing human pressure on land for production of food crops. To meet this increasing demand for green fodder; one of the alternatives is hydroponic fodder to supplement the inadequate and low quality pasture resources [4]. It was projected to evaluate the biomass performance of different crops under hydroponic fodder production system at ArbaMinch Agricultural Research Center.

* Corresponding author: Tessema Tesfaye Atumo; Email: tessema4@gmail.com
Southern Agricultural Research Institute, Arba Minch Agricultural Research Center, Feed and Nutrition Program, P.O. Box 2228, Arba Minch, Ethiopia.

2. Material and methods

Evaluation of different crops hydroponic biomass yield under fertigated condition was conducted at ArbaMinch Agricultural Research Center laboratory during May-July 2019. The experiment was laid out in completely randomized design with three replications and five crops in fertilized and non-fertilized condition as treatments. The crops included in the treatment were maize (*Zea mays*), oat (*Avena sativa*), cowpea (*Vigna unguiculata*), lablab (*Lablab purpureus*), and common bean (*Phaseolus vulgaris*) and the experiment was repeated three times. Good quality seeds with less than 12-14% moisture were selected and weighed. Seeds were washed in tap water by stirring with wooden stick manually to remove chaffs and dirt. The seeds of 500 gram from each crop were then soaked in tap water for 24 hours [3]. Water was then drained and the seeds were kept in gunny bags for 24 hours for germination [5]. After germination, each type of seeds were weighed and placed onto 2 different trays of 0.5 m^2 which one was fertilized and the other not fertilized and kept on the sprout section of hydroponic fodder system. Fertilizer amount applied was 0.01 kg/m^2 urea in watery form. The sprouting time recorded and also plant height measurement was undertaken since sixth day of the seed germination. Completely randomized design used to layout the treatment and the data was analyzed using Duncan's multiple range test (DMRT) and also simple statistical analysis was used to compare mean values of the hydroponics system.

3. Results and discussion

3.1. Time of sprouting

The result in Figure 1 shows that the sprouting date among different crops varied and maize took the longest day to be sprouted. Lablab germinated in the shortest day among other crops in the test. Thus, maize took 72, oats 48, common bean 36 and lablab 24 hours to be sprouted after soaking. Sprouting in different dates for different crop seeds after soaking may be due to the seed size, moisture content, and healthiness of the endosperm and crop types. Grains took relatively longer days to sprout than pulses in the experiment.

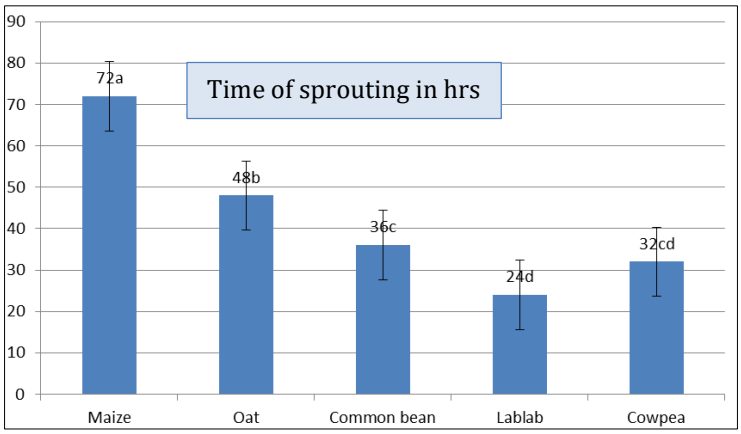

Figure 1 Sprouting time of seeds

3.2. Shoot growth of hdroponics

The shoot length presented in Table 1 revealed that five plants measured after 12 days of daily watering varied with fertilizer and without fertilizer within crop seeds and between seeds. Common bean gained the higher shoot length among other crops in the test whereas maize response for fertilizer application was higher than others. Thus, maize gained 17% for fertilizer application was higher gain in test and no gain for fertilization in lablab hydroponics.

The shoot length variation among crops under hydroponics fodder production system reported before [6] as maize was the best shooting crop. Depending upon the type of grains, the hydroponics fodder looks like a mat of 11-30 cm height by the end of the germination period of about 8-days and 4.6 folds fresh yield of maize fodder was observed during our experiment [5]. The mean shoot length ranging from 20.5-39.5 cm was quite more than the report before.

Table 1 Shoot length and the gain of fertilization in hydroponic fodder system

Crop type	shoot length in cm			
	Fertilizer	No Fertilizer	Mean	% gain of fertilizer
Maize	28	24	26	17%
Oats	21	20	20.5	5%
Lablab	34	34	34	0%
Common bean	42	37	39.5	14%
Cowpea	24	21	22.5	14%

3.3. Weight of hydroponic fodder

Weight gain of different crops under fertiligated condition with and without fertilizer is presented in Table 2. All three harvests pooled mean also showed that, common bean produced maximum green fodder yield of 5.92 kg kg^{-1} of seed which was followed by lablab (4.8) and maize (4.4). It was similar with grain maize (5.37 kg kg^{-1} of seed), and grain cowpea (5.29 kg kg^{-1} of seed). Weight gain advantage of 336%, 262%, 380%, 492% and 251% recorded on mean value of maize, oats, lablab, common bean and cowpea hydroponics over seed. The fertilizer application had an advantage over non fertilization in hydroponic system that fertilizer application gain over the mean value of maize, oats, lablab, common bean and cowpea was 5%, 13%, 15%, 6%, and 5%, respectively. This was reported before by different scholars [6]; [7]. Different crops perform differently in hydroponic green fodder yield [7] . Small cereals like oats and barley were considering for less water consumption [8]. Nutrient application is one of the major inputs required for hydroponic production [9] foliar nitrogen application significantly improves hydroponic green fodder yield [10].

Table 2 Weight gain of hydroponic crops under fertigated and non fertigated condition

Biomass weight in Kilogram				
Crop seed type	Fertilizer	No Fertilizer	Mean	Gain % from Seed
Maize	2.227	2.128	2.1775	1.6775
Oats	1.929	1.686	1.8075	1.3075
Lablab	2.583	2.214	2.3985	1.8985
Common bean	3.045	2.875	2.96	2.46
Cowpea	1.795	1.715	1.755	1.255

3.4. Correlation of weight gain with shoot growth

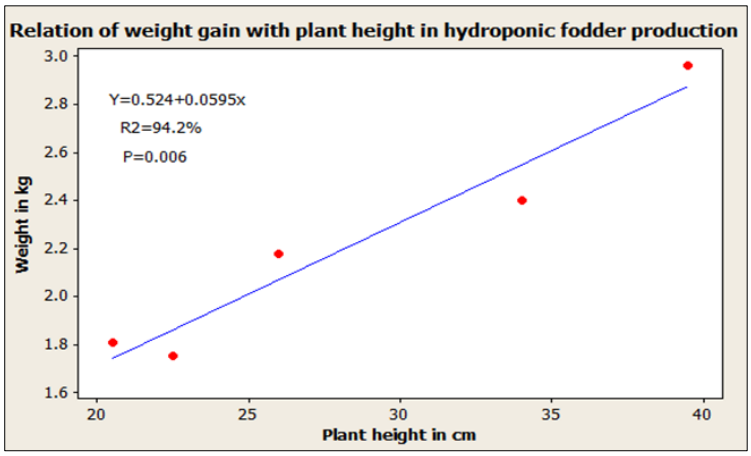

Figure 2 Association of weight gain height of hydroponics

In hydroponic fodder production the weight gain of the fodder could be directly from the shoot and root growth. Thus the regression analysis shown that weight gain highly (P<0.001) related to plant height at 94.2% regression value. In the present study the regression result revealed that each unit gain of the weight was due to 0.0595 unit increment in height (Figure 2).

3.5. Partial Budget Analysis

Partial budget analysis [11] presented in the Table 3 showed that the higher net revenue attained in hydroponic fodder production than grain seed production in the same plot of land. Fixed costs not considered for both hydroponic and grain seed production whereas variable costs included getting net revenue of the production. The net revenue of hydroponic production in 45 m^2 area was 83000 ETB per year while 57400 ETB for grain production. This could show that hydroponic forage production is higher by 30.84% than grain production.

Table 3 Partial budget analysis of hydroponic fodder in 45 m^2 production area

Descriptions	**Hydroponic Fodder (45 m^2)**	**Grain Yield (45 m^2)**
Shade construction	3600	0
Watering cane	300	0
Tray	375	0
Seed purchase (15ETB/kg)	1856.25	1856.25
Land rent	0	8000
Total Fixed costs(TFC)	6131.25	9856.25
Water	500	0
Wage payment	6400	9600
Urea (14 ETB/kg)	100	1500
NPS(14 ETB/kg)	0	1500
Total Variable Costs(TVC)	7000	12600
yield(ton/12 months)	45	3.5
Total Revenue(TR); (HF=2ETB/Kg, GY=20ETB/kg)	90000	70000
Net Revenue(NR=TR-TVC)	83000	57400

HF=hydroponic fodder GY=grain yield

4. Conclusion

The findings of this experiment to evaluate the hydroponic fodder production shown that, maize, oats, cowpea, common bean and lablab were identified as best performing crops under hydroponics for getting higher green fodder yield and foliar nitrogen application facilitated the growth and development of hydroponics. Thus, hydroponic fodder production could be the option for city agriculture especially in smallholder poultry business for young entrepreneurs, less land holding farmers, elders and women and even other interested groups under urban agriculture. Nutritional digestibility and nutrient demand may be considered further by animal nutritionists.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest.

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