RESEARCH ARTICLE

Evaluation of fodder crops for hydroponic green fodder potential

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Soil-based agriculture is now experiencing challenges due to numerous anthropogenic reasons, such as deforestation, urbanization and industrialization. Scientists have therefore established a new alternative solution to the farming system, named as soil-less or hydroponic cultivation. Keeping in mind this situation an experiment was conducted to evaluate the best fodder crop for hydroponic green fodder potential at CSI, NARC, Islamabad under laboratory conditions in which comparative study of green fodder was done on seven treatments with three replications in plastic trays of size 12 × 18 inches. This research study was performed in completely randomized design (CRD). The temperature during experiment was (30 ± 10°C). The treatments were T1=Maize (300 g), T2=Oat (300 g), T3 Sorghum, T4=Maize+Oat (150+150 g), T5=Oat+Sorghum (150+150 g), T6=Millet+Oat (150+150 g) and T7=Maize+Sorghum (150+150 g). The water was applied three times a day and the temperature was also noted thrice a day. The results revealed that maximum amount of green fresh produce were recorded as for millets+oat, maize and oat with 888.00 g, 883.53 g, and 727.21 green fresh yield/tray respectively. From the current study it is concluded that producing green fodder in indoor condition maize and oat may be used as they produce more green fodder. Further it is stated that combination of maize and oat may be used for better production and water use efficiency under hydroponic condition.

Key Words: *Hydroponic; Fodder; Soil-less cultivation; Soil based cultivation*

INTRODUCTION

Soil provides base for crop production [1-3]. So, it is a necessary component [4]. It is a non-renewable source that is being deteriorated and degraded day after day. Moreover, Natural as well as anthropogenic activities deteriorates soil quality and thus degrade it for agricultural use [5]. Agriculture sector is directly linked with soil while most of the agriculture land is degraded [6,7]. This alternative approach "hydroponic" is a commonly and regularly used technique that offers a significant degree of control of the elemental root environment for growing plants without soil. The process has a fascinating history of growth and use dating back to the mid-18th century, although the growth of plants in water rich in nutrients may have dated back to the early history of humanity. Using the solution culture technique, the determination of the essential elements needed by plants was found [8]. Typically, the hydroponic fodder device consists of shelf structures on which material or plastic trays are stacked. A coating of seed is scattered over the base of the trays after soaking overnight. The seeds are kept moist, but not saturated, during the growing cycle. Moisture and sometimes nutrients are supplied to them, usually through drip or spray irrigation. Drainage is facilitated by holes in the trays and the waste water is stored in a tank. Due to the shrinking land size and growing population, hydroponics is gaining importance [9].

Oat (*Avena Sativa* L) is a cereal grain that is one of the world's most significant sources of animal feed for livestock. Oat fodder grown hydroponically is high in starch-low fiber, making it an easily digestible feed. Sorghum (*Sorghum bicolor* L) is an important crop which can be used for multipurpose [10-12]. Millets (*Pennisutum typiod* L) locally named as Bajra is an important food and feed crop. In Pakistan millets are grown in tropical areas like D.I Khan. Millets are also used as a fodder crop. Pearl millet is a short day summer crop and is resistant to drought. It grows well in hot dry climate. It can grow well on poor sandy soil where no other crop can be produced. Millet seems to be highly tolerant to salinity stress and therefore can be cultivated in salt - affected areas [13].

Maize is a commonly cultivated grain crop worldwide. Maize is used both for feed and food purpose and it is 3rd most important cereal crop [14-21]. Fodder maize and grain maize were found to be suitable for the production of hydroponic fodder and greater shoot length, root length, green fodder yield, dry matter yield and crude fiber yield were reported [22]. Having numerous difficulties with soil-based cultivation, scientists have established a substitute for cultivation system that is to say soil-less farming or hydroponics. Keeping in mind this situation an experiment was carried out to evaluate the best fodder crop for hydroponic green fodder potential.

MATERIALS AND METHODS

A laboratory experiment was performed at Fodder Research Program, Crop Science Institute, National Agricultural Research Centre (CSI, NARC), Islamabad in July 2018. This experiment was carried out under completely randomized design (CRD) having three replications. Seven fodder crops i.e. Maize (300 g), Oat (300 g), Sorghum (300 g), Maize+Oat (150+150 g), Oat+Sorghum (150+150 g), Millet+Oat (150+150 g) and Maize+Sorghum (150+150 g) were considered in the study using plastic trays of 18 × 12 inches. Seeds were primed for 24 hours and were spread in trays equipped with blotting paper. Water was sprayed twice a day and temperature of the lab was noted daily. After seven days' interval the seeds were fully emerged after 12 to 14 days of sowing the seedlings were harvested for green fodder yield followed by oven drying for dry matter yield.

Data collection

<u>Days to emergence:</u> Days to emergence data was recorded after three days from seed priming.

<u>Plant height (cm):</u> The plant height was calculated in centimeters from root to shoot by using scale. In each tray five plants were selected randomly and their mean height was averaged.

<u>Root length (cm):</u> Root length was calculated in centimeters from root-shoot joint to apex of the root.

<u>Number of leaves</u>: The data concerning number of leaves were recorded by counting leaves and their means were calculated.

<u>Green fodder weight (g):</u> Green fodder weight was calculated at 14 days after sowing. A triple beam balance was used to weigh the total green fodder including roots.

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Dry fodder weight (g): Total green fodder was oven dried for 24 hours at 60°C and were weighed using weight balance.

Statistical analysis: The data were statistically analyzed by means of Fisher analysis of variance technique and the treatment means were compared by using the least significant difference test (LSD) at 0.05 probabilities [23].

RESULTS AND DISCUSSION

Days to emergence

Data regarding days to emergence of various hydroponic treatments is presented in Table 1 and Figure 1. Statistical analysis of the data revealed a non-significant ($P>0.05$) effect of various fodder crops on days to emergence. Mean data revealed those maximum days to emergence (7) were taken by T-2 (oat) while minimum days to emergence (03) were taken by T-1 (Maize). Maize takes fewer days to emergence as it is a Kharif crop which needs high temperature as high temperature was recorded during the experiment. Oat took maximum days to emergence because it is Rabi crop and need low temperature while the experiment was conducted Kharif season and the temperature was high. Emergence of different crops produced hydroponically is based on nutrient accumulation and also depend upon the Aluminum concentrations in the water [24]. Emergence can be significantly increased by using water containing sodium chloride and magnesium chloride [25].

TABLE 1

Days to Emergence, plant height (cm) and root length (cm) of various hydroponics.

Treatments	Days to emergence	Plant height (cm)	Root length (cm)
T1(Maize)	3	12^{ab}	5.6^{ab}
T2(Oat)	7	11^{abc}	3.61^{bcd}
T3(Sorghum)	4	4^{d}	2.15^{d}
T4 (Maize+Oat)	5	14^{a}	6.33^{a}
T5(Oat+Sorghum)	6	7^{cd}	2.28^{d}
T6(Millet+Oat)	6	8^{bcd}	2.73^{cd}
T7(Maize+Sorghum)	4	13^{a}	5.21^{abc}
LSD (P<0.05)	NS	2.0931	1.1793

Mean values of the same category followed by different letters are significant at P<0.05 level.

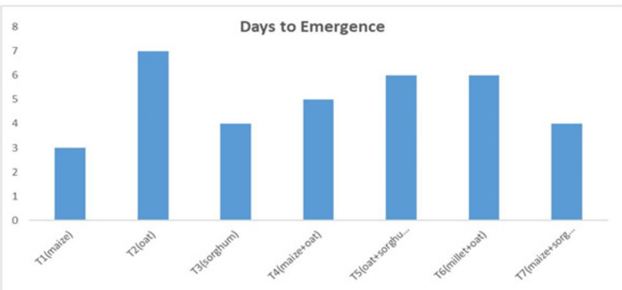

Figure 1) *Days to emergence of various fodder crops in hydroponic experiment*

Plant height (cm)

The data regarding plant height of various hydroponics treatments is presented in Table 1 and Figure 2. Statistical analysis of the data indicated that plant height of various hydroponic treatments was significant ($P<0.05$). Mean values showed that maximum plant height (13.66 cm) was recorded for T-4 (maize+oat) while minimum plant height (5.11 cm) was recorded for T-3 (sorghum). This showed that the applying of water can increase the plant height and produce more yield. The maximum plant height of maize is its genetic ability because maize is a tall crop and also its growth is so much vigorous than other crops. That's why maximum plant height was recorded in maize. Our findings are in similarity with that of Abdus et al. [26].

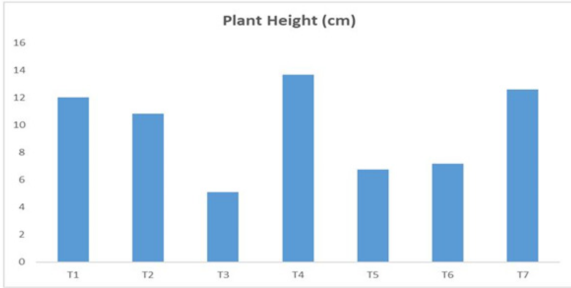

Figure 2) *Plant height of various hydroponic fodder crops*

Root length (cm)

Data regarding root length of various hydroponics is presented in Table 1 and Figure 3. Statistical analysis of the data revealed that root length for various hydroponics was significant ($P<0.05$). Mean values showed maximum root length (10.44+2.12 cm) for T-4 (maize+oat) respectively while minimum root length (2.15 cm) was recorded for T-3 (sorghum). The maximum root length of maize was due to its genetic ability because its root grows deep in the soil and explores deep layers of soil in order to get water from the very deep and also maize has intricate system of roots containing embryonic as well as post embryonic roots. Although all root forms of cellular structures are comparable, unique mutants suggest complex genetic programmes that control the development of the maize root system. Fodder maize and grain maize were found to be suitable for hydroponics fodder production and recorded higher root length [22]. Root growth in hydroponics was greater as compared to aeroponics due to limited availability of nutrient and water [27].

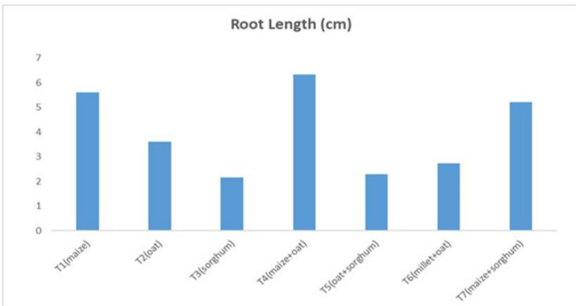

Figure 3) *Root length of various hydroponics*

Number of leaves

Data regarding number of leaves of various hydroponics is presented in Table 2 and Figure 4. Statistical analysis of the data showed that number of leaves for various hydroponics was non-significant ($P>0.05$). Mean values of the data showed that maximum number of leaves (4) was recorded for T-3 (sorghum) while minimum number of leaves (1) was recorded for T-2 (oat). The number of leaves in grown plants in ultra - violet light was substantially lower than that of plants in other classes [28].

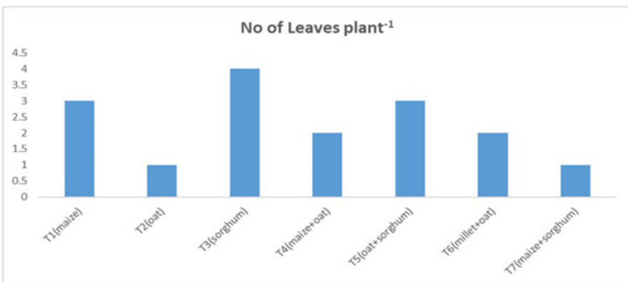

Figure 4) *Number of Leaves of various hydroponic crops*

TABLE 2

No of leaves plant^{-1}, green fodder yield (g) and dry fodder yield (g)

Treatments	No of Leaves plant-1	Green fodder yield (g)	Dry fodder Yield (g)
T1(Maize)	3	883.53^{a}	135.6
T2(Oat)	1	727.21^{b}	143.6
T3(Sorghum)	4	594.75^{c}	151.9
T4(Maize+Oat)	2	533.82^{d}	156.4
T5(Oat+Sorghum)	3	583.16^{c}	191.8
T6(Millet+Oat)	2	888.00^{a}	163.3
T7(Maize+Sorghum)	1	456.00^{e}	181.4
LSD (P<0.05)	NS	18.038	NS

Mean values of the same category followed by different letters are significant at P<0.05 level

Green fodder yield (g)

The data regarding green fodder yield of various hydroponic treatments is presented in Table 2 and Figure 5. Statistical analysis of the data revealed that green fodder yield of various treatments was significant (P<0.05). Mean values of the data indicated that maximum green fodder yield (888.00 g) was recorded for T-6 (Millet+Oat) while minimum green fodder yield (456.00 g) was recorded for T-7 (maize+sorghum). Our results are in similarity with the findings of [29]. Green fodder can indeed be grown using hydroponic technology in 8 days, from plantation to harvest [30].

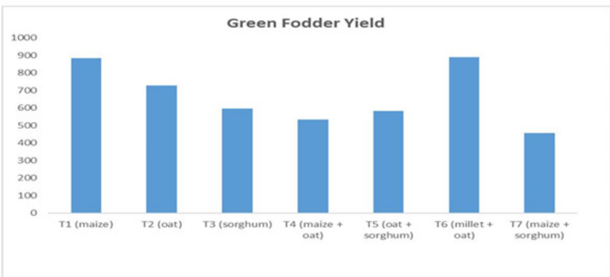

Figure 5) *Green Fodder Yield of various hydroponic fodder crops*

Dry fodder yield (g)

Data regarding dry fodder yield of various treatments is presented in Table 2 and Figure 6. Statistical analysis of the data showed that hydroponically dry weight of different treatments was non-significant (P>0.05). Mean values showed that the maximum dry fodder yield (191.88 g) was recorded for T-5 (oat+sorghum) while minimum dry fodder yield (135.60 g) was recorded for T-1 (Maize). The decrease in total dry matter will cause increase in total biomass and nutrient content [31].

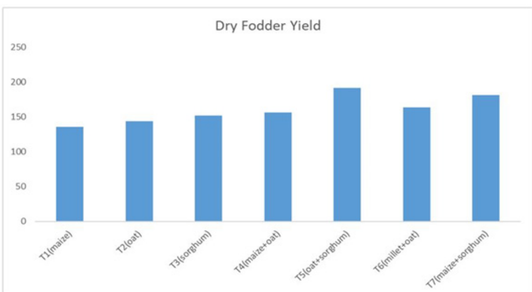

Figure 6) *Dry Fodder Yield of various hydroponic crops*

CONCLUSION

From the current study it is concluded that producing green fodder in indoor condition maize and oat may be used as they produce more green fodder. Further it is stated that combination of maize and oat may be used for better production and water use efficiency under hydroponic condition than the other tested crop. Maize crop, however, is considered to be the best alternative that can be used for hydroponic green fodder production with lower water usage; especially maize seeds are largely accessible in the market at lower prices than the others, reducing the cost of the production of hydroponic fodder.

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