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Effect of hydroponically grown substrates on fodder production under protected environment

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Abstract

Fodder plays an important role in livestock feed to providing required nutrients for milk and meat production. Mostly wheat-grass is cultivated for its seeds, a cereal grain worldwide used as staple food. In Pakistan year-round fodder availability is very important especially in slack period. Hydroponic is an improved method to grow wheat-fodder without soil by using nutrients water in soilless substrate. The process of growing wheat-fodder hydroponically allows the control of climatic conditions for optimum growth. In hydroponics agriculture, only two weeks are required for the production of wheat-grass due its fast growing habit under protected environment. Keeping in view the importance of fodder, an experiment was conducted at Hydroponic Research Station Rawat, Institute of Hydroponic Agriculture (IHA), PMAS Arid Agriculture University Rawalpindi. Nine plastic trays (0.3x0.15x0.076 m) were selected in the experiment with three different types of substrates i.e. coco, pasteurized soil and sand were used to grow wheat-fodder. One plants cluster was selected from each tray and data recorded for various crop growth parameters like germination rate, cluster height, number of tillers, root length, fresh weight and dry weight was statistical analyzed by using Complete Randomized Design (CRD). It was concluded from the study that coco proved to be a better substrate as compared to sand and pasteurized soil.

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Introduction

Techniques used to grow crops without soil are called as soilless-culture. It consists of pure water and substrate culture (Butt & Varis, 1999). A suitable substrate is an important for optimum growth of hydroponically grown plants (Kubota *et al.,* 2012). Growing media, "substrates" provide a root environment had properties that ensure an adequate aeration and nutrient water. In the horticultural industry, generally, mixtures of growing media (Coco, sand and perlite) are used. Organic or inorganic materials can be used as substrate (Savvas *et al.,* 2018).

Rockwool with low weight have a better water holding capacity. It hold adequate quantity of water in its pore space. Different irrigation methods are under used to supply water and nutrients to the crops (Nichols *et al.,* 2013). Use of soilless substrates in hydroponic systems for production of crops is increasing worldwide. Substrates often increase plant growth and yield in many crops, reduce the incidence of soil-borne diseases and increase the efficiency of water and nutrient use (Quintero *et al.,* 2011). Different substrate materials and their combine have been used (Jayasinghe *et al.,* 2010; Ceglie *et al.,* 2011; Carmona *et al.,* 2012). They includes; perlite, coco peat, clay and sand (Clemmensen 2004).

Soilless growing media is easy to handle and provide an environment that is suitable for crop growth. Different organic and in-organic matters are used as growing media (Olle *et al.,* 2012). For water holding capacity and correct balance of air different kind of growing materials are used for the plants growth (Nair *et al.,* 2011). Sand also a good substrate provide natural pH and maximum air space while Coco is widely used as substrate for the production of different plants (Caballero *et al.,* 2007).

Heins *et al.* (2015) reported that the electricity requirement for the production of hydroponic fodder is much lower. Naik and Singh (2013) found that root length of hydroponic fodder is much smaller than in a traditionally grown fodder, which means higher numbers of plants per unit of space. Fazaeli *et al.* (2012) reported that comparative evaluation of hydroponic fodder produced by using tap water or nutrient solution revealed that growing of sprouts by nutrient solution had high value of crude protein and ash contents as compare to the sprouts grown by tap water. The Ca, K, P, Mg, Na, Fe, Cu and Zn concentrations were higher in hydroponics fodder produced using nutrient solution.

Hydroponically grown fodder, one is assured of the quality and quantity that is being consumed. This consistency of feed can lead to better-tasting end products of consistent quality, which is one of the major goals of the beef producers. Similarly consistency in feed can also increase the quality of meat and other products of swine and poultry. Hydroponic fodder production is a way to substantially improve the quality of animal products (Maxwell Salinger, 2013).

Global trend in animal production indicates a rapid and massive increase in the consumption of livestock products. By the end of 12th Plan, demand for milk is expected to increase to 141 million tons and for meat, eggs and fish together to 15.8 million tons. (Planning commission of India, 2011). Periurban livestock farming and emerging fodder markets are indicators of fast changing economic scenario in livestock sector (Mishra *et al.,* 2005). Generally-closed re-circulating hydroponic systems, can use 20-40% less water and nutrients than open systems, but are more difficult to monitor and maintain. This difficulty arises from ion accumulation during the nutrient solution recirculation (Christie, 2014).

In Pakistan offseason quality green fodder is not available throughout the year. Livestock farmers demand for fresh green fodder. However fodder that is available is too much expensive and of low quality. Pakistan's urban environment has a small land holding. Mostly all of the area of the land is constructed with rooms, balconies, corridors and drawing rooms. Suitable fertile land for fodder production is not available. Present study has been planned to test different substrates for wheat-grass production under protected environment in temper glass clad greenhouse to provide food for livestock during slack period of the year within minimum time of 2-3 week while in the field condition it requires 2-3 month in cropping season while offseason production in field condition is impossible. The aim of this experiment was to produce year-round fodder to the livestock industry in the areas where fertile soil is not available or faraway from site like in urban environment.

Materials and methods

Study area

Research was carried out at Hydroponic Research Station, Institute of Hydroponic Agriculture, PMAS-Arid Agriculture University Rawalpindi during the year 2018-19. Study area falls in the jurisdiction of district Rawalpindi *Pothwar* region of North Punjab, Pakistan.

Testing of soilless substrates

Nine plastic trays (0.3x0.15x0.076 m) were selected in the experiment with three different types of substrates/treatments T_1 (Coco), T_2 (Pasteurized soil), T_3 (sand). Seeds of wheat-grass were placed in the trays and irrigated with RO water after sowing. Water used to irrigate the grass with managing pH of 5.5 and EC of 2.1 dS/m.

Plant growth parameters under hydroponics system

Plant growth measuring variables including; germination rate, cluster height, number of tillers, length of roots, fresh weight and dry weight were recorded to find the effect of hydroponically grown substrate on fodder production under protected environment. One grass cluster was selected from each tray and data recorded for each experimental unit, was statistically analysed.

Results and discussion

Experiment was conducted for the comparison of different substrates (coco, pasteurized soil and sand). Data recorded during study was statistical analysed by using Completely Randomized Design (CRD) with the help of appropriate software Statistic 8.1 at 5% level of probability. Measuring variables including; germination rate, cluster height, number of tillers, root length, fresh weight and dry weight are discussed as;

Germination rate (%)

Mean germination rate (Table 1) in treatment T_1, T_2, and T_3 was observed 68.33, 13.66 and 54.66% respectively. Maximum germination rate (68.33%) was measured in treatment (T_1) coco, Second highest germination rate (54.66%) was observed in treatment (T_3) sand while minimum germination rate (13.66%) was observed in treatment (T_2) pasteurized soil.

Results showed that treatment (T_1) coco was highly significant with treatment (T_2) pasteurized soil and (T_3) sand while treatment (T_2) pasteurized soil was also significant with (T_1) coco and (T_3) sand at 5% level of probability. The mean value of germination rate was at par with the findings of (Khoneva *et al.*, 2018) who reported that maximum germination rate (93%) was observed in coco substrate.

Table 1. Effect of different substrates on germination rate.

Treatments	Germination rate (%)
T_1 Coco	68.33 a
T_2 Pasteurized soil	13.66 c
T_3 Sand	54.66 b
LSD	12.09

Mean with similar letters are statistically non-significant at 5% level of probability.

Cluster height (cm)

Mean cluster height (Table 2) in treatments T_1, T_2 and T_3 were recorded 26, 12.6 and 22cm respectively. Maximum cluster height (26cm) was measured in treatment (T_1) coco while treatment (T_3) was at second highest cluster height (22cm). However the minimum cluster height (12.6cm) was measured in treatment (T_2) pasteurized soil.

Results showed that treatment (T_1) coco was highly significant with treatment (T_2) pasteurized soil and (T_3) sand while treatment (T_2) pasteurized soil was also significant with treatment (T_1) coco and treatment (T_3) sand at 5% level of probability. In the present experiment, cluster height in treatments (T_1) and (T_3) was in line with the findings of Naik *et al.*, 2015 who reported that wheat-grass fodder height was 20-30cm.

Table 2. Effect of different substrates on cluster height (cm).

Treatments	Cluster height (cm)
T_1 Coco	26.0 a
T_2 Pasteurized soil	12.6 c
T_3 Sand	22.0 b
LSD	3.5

Mean with similar letters are statistically non-significant at 5% level of probability.

Number of tillers (No.)

Mean number of tillers (Table 3) in treatments T_1, T_2 and T_3 were observed 108.33, 23.66 and 96.33 respectively. Maximum number of tillers (108.33) was recorded in treatment (T_1) coco, treatment (T_3) was at second position (96.33). Minimum number of tillers (23.66) was calculated in treatment (T_2) pasteurized soil.

Results showed that treatment (T_1) coco was non-significant with treatment (T_3) sand and significant with (T_2) pasteurized soil while treatment (T_2) pasteurized soil was significant with treatment (T_1) coco and treatment (T_3) sand at 5% level of probability.

Table 3. Effect of different substrates on number of tillers.

Treatments	Number of tillers
T_1 Coco	108.33 a
T_2 Pasteurized soil	23.66 b
T_3 Sand	96.33 a
LSD	21.9

Mean with similar letters are statistically non-significant at 5% level of probability.

Root length (cm)

Mean length of roots (Table 4) in treatments T_1, T_2 and T_3 was recorded 5.66, 3.0 and 4.66cm respectively. Maximum root length (5.66cm) was measured in treatment (T_1) coco, second highest root length (4.66cm) was recorded in treatment (T_3) while the minimum root length (3.0cm) was measured in treatment (T_2) pasteurized soil.

Results showed that treatment (T_1) coco was non-significant with treatment (T_3) sand and significant with treatment (T_2) pasteurized soil while treatment (T_2) pasteurized soil was non-significant with treatment (T_3) sand and significant with treatment (T_1) coco at 5% level of probability. The mean values of root length in treatment T_1, T_2 and T_3 are less than the findings of Donald Wetherell (1988) who reported that hydroponically grown wheat root system develops 15-25cm.

Table 4. Effect of different substrates on length of root (cm).

Treatments	Length of root
T_1 Coco	5.66 a
T_2 Pasteurized soil	3.0 b
T_3 Sand	4.66 ab
LSD	1.88

Mean with similar letters are statistically non-significant at 5% level of probability.

Fresh weight (g)

Mean fresh weight (Table 5) in treatments T_1, T_2 and T_3 were observed 383.33, 71.66 and 313.33g respectively. Maximum fresh weight (383.33) was measured in treatment (T_1) coco while treatment (T_3) sand was at second position with fresh weight of 313.33g while minimum fresh weight (71.66g) was measured in treatment (T_2) pasteurized soil.

Results showed that treatment (T_1) coco was highly significant with treatment (T_2) pasteurized soil and treatment (T_3) sand while treatment (T_2) pasteurized soil was significant with treatment (T_1) coco and treatment (T_3) sand at 5% level of probability

Table 5. Effect of different substrates on fresh weight (g).

Treatments	Fresh weight (g)
T_1 Coco	383.33 a
T_2 Pasteurized soil	71.66 c
T_3 Sand	313.33 b
LSD	60.2

Mean with similar letters are statistically non-significant at 5% level of probability.

Dry weight (g)

Mean dry weight (Table 6) in treatments T_1, T_2 and T_3 were observed 140, 33.33 and 100g respectively. Maximum dry weight (140g) was measured in treatment (T_1) coco while treatment (T_3) sand was second position fresh weight (100g) while the minimum fresh weight (33.3g) was measured in treatment (T_2) pasteurized soil.

Results showed that treatment (T_1) coco was highly significant with treatment (T_2) pasteurized soil and treatment (T_3) sand while treatment (T_2) pasteurized soil was also significant with treatment (T_1) coco and treatment (T_3) sand at 5% level of probability. On an average weight loss in dehydrating fresh fodder was observed about 60%, which is at par with Chung *et al.,* (1989) who concluded that dry weight losses were 9.4-18%.

Table 6. Effect of different substrates on dry weight (g).

Treatments	Dry weight (g)
T_1 Coco	140 a
T_2 Pasteurized soil	33.33 c
T_3 Sand	100 b
LSD	33.2

Mean with similar letters are statistically non-significant at 5% level of probability.

Conclusions

It was concluded from the study that highest germination rate, cluster height, number of tillers, root length, fresh weight and dry weight were obtained in treatment T_1 coco in greenhouse conditions.

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