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Comparison study of static nutrient film technique with drip irrigation and pasteurized soil for wheat grass production under greenhouse condition

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Abstract

Green fodder is a famous animals feed that is made from green crops like legume crops, cereal crops, grass crops or even tree based crops. Green fodder provides required nutrients for milk production. Wheat is one of the most popular fodder. 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. Nutrient film technique is an improved method to grow wheat-fodder without soil by using nutrients water in channels. 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. The experiment consist of two sizes of static PVC pipes (7.6 & 10.1 cm) and static steel trays (8.8 & 12.5 cm) during the comparative study of static NFT with drip irrigation and pasteurized soil for wheat grass production. Five clusters were selected from each Channel 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 NFT proved to be a better technique as compared to drip and pasteurized soil.

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Introduction

The population of the world is expected to increase 9.7 billion by 2050. It is reported that 50% of the area that suitable to grow crops in the world will not be available for agriculture. Therefore, the problem of food disaster increases day by day (United Nations, 2017). Growing of plants without soil is known as hydroponics (Savvas, 2003).

Nutrient film technique (NFT) is a technique of hydroponic agriculture in which nutrients required for plant growth is re-circulating in the channels containing plants. A significant problem facing world agriculture is the variation in crop yields from year to year due to variation in environmental stresses like drought, flooding, high wind velocities as well as high or low temperatures. Damage caused by stresses can also result in physiological disorders in crop plants (Xu *et al.,* 2015). In the absence of soil, nutrient solution is used for the growth of plants in Nutrient Film Technique (Resh, 2013).

Keeping in view the environmental perception, crop production in nutrient film technique give maximum yield, greater plant existence rates and low water wastage. From a producer point of view these advantages of environment offer greater profits ensuring maximum yield and less wastage of resources (i.e., water and labor). Nutritionally, some studies have indicated that crop production in nutrient film technique give superior nutritional quality (Treftz, C. and Omaye, S.T., 2015).

There are many techniques used for hydroponics that can utilize in the construction of a system. The techniques will depend largely on the type of crop (leafy or fodder) as well as any limitations of system or growing space. Generally there are two types of techniques: static and re-circulating. While these hydroponics types may share many aspects, including design, they fundamentally differ in order to manage the nutrient solution (Kruchkin, 2013). The technique for production of hydroponic fodder contains unsoiled, complete, integral, raw, and feasible seeds of high quality (Starova Jeton, 2016). In static NFT, the nutrient water is not re-circulated and it is easy to monitor and maintain the pH and EC (Macabo *et al*, 2013). An EC of 1.5 dS/m has been recommended for nutrient film technique (Resh, 2012). A pH in the range of 5.8-6.5 has been recommended for crops grown hydroponically due to sufficient availability of all the nutrients in this range (Jones, 2004). Morsy *et al.*, (2014) reported that hydroponics fodder is highly delicious and the germinated seeds embedded in the channels are also consumed along with the shoots of the plants without any nutrient wasting. Hydroponics fodder is extremely high in protein and energy. There are several benefits of growing crops under hydroponics system over conventional agriculture i.e. high production and quality yield (Silberbush and Asher, 2001).

Materials and methods

Study area

Experiment was conducted 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.

Design of experiment

Static NFT consists of two PVC pipes size (7.6 & 10.1 cm) and steel trays (8.8 & 12.5 cm) while their comparison was made with drip irrigation system and pasteurized soil. Polystyrene trays were fitted in the rectangular holes (1'×6") made on trays, PVC pipes and on coco-slabs. Rockwool was used as a supporting media placed in the polystyrene trays. Air pumps were used to provide oxygen to the wheat-fodder in static NFT. Static pipe & trays were filled with water manually, slabs were irrigated through drip irrigation. For growing of wheat fodder in soil, Plastic pot were used as carrier and were irrigated manually. EC and pH of irrigation was maintained at 1.7dS/m and 5.5.

Experimental treatments

Experiment consist of T_1 (Static pipe 7.6 cm dia.), T_2 (Static pipe 10.1 cm dia.), T_3 (Static Tray 8.8 cm width), T_4 (Static tray 12.5 cm width), T_5 (Drip irrigation system), T_6 (Pasteurized soil). Five clusters were selected from each treatment and data recorded from each treatment was statistically analyzed.

Results and discussions

Experiment was conducted for comparison of static NFT with drip irrigation system and pasteurized soil under protected environment. Data recorded during study was statistical analyzed 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, T_3, T_4, T_5 and T_6 was observed 36.8, 54.8, 81.0, 86.4, 76.0 and 68.8% respectively. Maximum germination rate (86.4%) was measured in treatment (T_4) Steel tray with 12.5 cm width, Second highest germination rate (81.0%) was observed in treatment (T_3) Steel tray with 8.8 cm width while minimum germination rate (36.8%) was recorded in treatment (T_1) Static pipe with 7.6 cm.

Results showed that treatment (T_4) Steel tray with 12.5 cm width was non-significant with treatment (T_3) Steel tray with 8.8 cm width and (T_5) drip irrigation system while it significantly differ with treatment (T_1) Static pipe with 7.6 cm, treatment (T_2) Static pipe with 10.1 cm and treatment (T_6) pasteurized soil 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 soilless culture.

Table 1. Effect of different treatments on germination rate.

Treatments	Germination rate (%)
T_1 Static pipe (7.6 cm)	36.8 d
T_2 Static pipe (10.1 cm)	54.8 c
T_3 Static steel tray (8.8 cm width)	81.0 a
T_4 Static steel tray (12.5 cm width)	86.4 a
T_5 Drip irrigation system (Coco slab)	76.0 ab
T_6 Pasteurized soil (Pots)	68.8 b
LSD	11.7

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

Cluster height (cm)

Mean cluster height (Table 2) in treatment T_1, T_2, T_3, T_4, T_5 and T_6 was observed 19.8, 22.0, 33.4, 37.2, 29.6 and 28.4% respectively. Maximum cluster height (37.2cm) was measured in treatment (T_4) Steel tray with 12.5 cm width, Second highest cluster height (33.4cm) was observed in treatment (T_3) Steel tray with 8.8 cm width while minimum cluster height (19.8cm) was measured in treatment (T_1) Static pipe with 7.6 cm.

Results showed that treatment (T_4) Steel tray with 12.5 cm width was non-significant with treatment (T_3) Steel tray with 8.8 cm width while it significantly differ with treatment (T_1) Static pipe with 7.6 cm, treatment (T_2) Static pipe with 10.1 cm, (T_5) drip irrigation and treatment (T_6) pasteurized soil at 5% level of probability. In the present experiment, cluster height in treatments T_2, T_5 and T_6 were in-line with Naik *et al.*, 2015 who reported that wheat-grass fodder height was 20-30cm.

Table 2. Effect of different treatments on cluster height.

Treatments	Cluster height (cm)
T_1 Static pipe (7.6 cm)	19.8 d
T_2 Static pipe (10.1 cm)	22.0 d
T_3 Steel tray (8.8 cm width)	33.4 ab
T_4 Steel tray (12.5 cm width)	37.2 a
T_5 Drip irrigation system (Coco slab)	29.6 bc
T_6 Pasteurized soil (Pots)	28.4 c
LSD	4.2

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

Number of tillers

Mean number of tillers (Table 3) in treatment T_1, T_2, T_3, T_4, T_5 and T_6 was observed 91.0, 130.4, 171.0, 175.8, 170.8 and 157.6% respectively. Maximum number of tillers (175.8) was observed in treatment (T_4) Steel tray with 12.5 cm width, Second highest number of tillers (171.0) was observed in treatment (T_3) Steel tray with 8.8 cm width while minimum number of tillers (91) was observed in treatment (T_1) Static pipe with 7.6 cm.

Results showed that treatment (T_4) Steel tray with 12.5 cm width was non-significant with treatment (T_3) Steel tray with 8.8 cm width, (T_5) drip irrigation system and treatment (T_6) pasteurized soil while it significantly differ with treatment (T_1) Static pipe with 7.6 cm, treatment (T_2) Static pipe with 10.1 cm at 5% level of probability.

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

Treatments	Number of tillers
T_1 Static pipe (7.6 cm)	91 c
T_2 Static pipe (10.1 cm)	130.4 b
T_3 Static steel tray (8.8 cm width)	171.0 a
T_4 Static steel tray (12.5 cm width)	175.8 a
T_5 Drip irrigation system (Coco slab)	170.8 a
T_6 Pasteurized soil (Pots)	157.6 ab
LSD	30.1

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

Root length (cm)

Mean root length (Table 4) in treatment T_1, T_2, T_3, T_4, T_5 and T_6 was observed 5.6, 9.6, 9.2, 14.8, 12.0 and 13.4% respectively. Maximum root length (14.8cm) was measured in treatment (T_4) Steel tray with 12.5 cm width, Second highest root length (13.4cm) was observed in treatment (T_6) pasteurized soil while minimum root length (5.6cm) was measured in treatment (T_1) Static pipe with 7.6 cm dia.

Results showed that treatment (T_4) Steel tray with 12.5 cm width was non-significant with treatment (T_6) pasteurized soil while it significantly differ with treatment (T_1) Static pipe with 7.6 cm, treatment (T_2) Static pipe with 10.1 cm, treatment (T_3) Steel tray with 8.8 cm width (T_5) drip irrigation system and at 5% level of probability. The mean values of root length in treatment (T_1, T_2, T_3 , T_4, T_5 and T_6) 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 treatments on root length.

Treatments	Root length (cm)
T_1 Static pipe (7.6 cm)	5.6 d
T_2 Static pipe (10.1 cm)	9.6 c
T_3 Static steel tray (8.8 cm width)	9.2 c
T_4 Static steel tray (12.5 cm width)	14.8 a
T_5 Drip irrigation system (Coco slab)	12 b
T_6 Pasteurized soil (Pots)	13.4 ab
LSD	2.0

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

Fresh weight (g)

Mean fresh weight (Table 5) in treatment T_1, T_2, T_3, T_4, T_5 and T_6 was measured in 218, 326, 454, 506, 424 and 384 gram respectively.

Maximum fresh weight (506g) was observed in treatment (T_4) Steel tray with 12.5 cm width, Second highest fresh weight (454g) was observed in (T_3) Steel tray with 8.8 cm width while minimum fresh weight (218g) was observed in treatment (T_1) Static pipe with 7.6 cm dia.

Results showed that treatment (T_4) Steel tray with 12.5 cm width was non-significant with treatment (T_3) Steel tray with 8.8 cm width while it significantly differ with treatment (T_1) Static pipe with 7.6 cm, treatment (T_2) Static pipe with 10.1 cm, (T_5) drip irrigation system and treatment (T_6) pasteurized soil at 5% level of probability.

Table 5. Effect of different treatments on fresh weight.

Treatments	Fresh weight (g)
T_1 Static pipe (7.6 cm)	218 e
T_2 Static pipe (10.1 cm)	326 d
T_3 Static steel tray (8.8 cm width)	454 ab
T_4 Steel tray (12.5 cm width)	506 a
T_5 Drip irrigation system (Coco slab)	424 bc
T_6 Pasteurized soil (Pots)	384 cd
LSD	63.32

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

Dry weight (g)

Mean dry weight (Table 6) in treatment T_1, T_2, T_3, T_4, T_5 and T_6 was observed 100, 130, 184, 202, 176 and 158 gram respectively. Maximum dry weight (202g) was observed in treatment (T_4) Steel tray with 12.5 cm width, Second highest fresh weight (184g) was observed in (T_3) Steel tray with 8.8 cm width while minimum fresh weight (100 g) was observed in treatment (T_1) Static pipe with 7.6 cm.

Results showed that treatment (T_4) Steel tray with 12.5 cm width was non-significant with treatment (T_3) Steel tray with 8.8 cm width, (T_5) drip irrigation system while it significantly differ with treatment (T_1) Static pipe with 7.6 cm, treatment (T_2) Static pipe with 10.1 cm, and treatment (T_6) pasteurized soil 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 treatments on dry weight.

Treatments	Dry weight (g)
T_1 Static pipe (7.6 cm)	100 d
T_2 Static pipe (10.1 cm)	130 cd
T_3 Static steel tray (8.8 cm width)	184 ab
T_4 Static steel tray (12.5 cm width)	202 a
T_5 Drip irrigation system (Coco slab)	176.0 ab
T_6 Pasteurized soil (Pots)	158 bc
LSD	31.0

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

Conclusions

It was concluded from the study that NFT has higher production of wheat-fodder as compared to the drip irrigation system and pasteurized soil as it has highest germination rate, cluster height, number of tillers, root length, fresh weight and dry weight were obtained in treatment (T_4)Steel tray with 12.5 cm width in greenhouse conditions.

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