Available online freely at www.isisn.org

Plant Science Journal

Print ISSN: 2227-5614 Online ISSN: 2227-5630

Journal by Innovative Scientific Information & Services Network

RESEARCH ARTICLE PLANT SCIENCE JOURNAL, 2019 8(1): 01-11. **OPEN ACCESS**

The use of some agricultural residues in the surface cultivation of Barley plants by microorganisms

Noura S. Soud[1*], Khaled K. Hegab[2], Galal M. Khalafalla[1], and Mohammed Z. Sedik[1]

[1]Agric. Micro. Dept., Faculty of Agric., Cairo University, **Egypt.**
[2]Agric. Eng. Dept., Faculty of Agric., Cairo University**, Egypt.**

***Correspondence:** Noura.soudy@yahoo.com

In order to improve the green fodder production under hydroponic conditions using agricultural residues and microorganisms, barley grains were grown in a hydroponic developing chamber for 8 days and were subjected to vegetation and chemical analysis. Productivity measured was carried out based on the contents of barley grains and hydroponic barley sprout (HBS) yield. The data revealed that the microbial counts recorded in rice straw were less than those recorded in bagasse. The counts were $2.8*10^4$, $5.8*10^6$, and $5.3*10^4$ CFU g^{-1} in rice straw, bagasse and barley grains respectively. While the fungal count reached to $1.4*10^2$, $3.0*10^4$ and $1.6*10^3$ CFU g^{-1} in same materials used. The microbial counts increased by 48%, 82% and 104% with inoculation with *Pseudomonas fluorescens, Saccharomyces cerevisiae,* and *Ps. fluorescens* + *S. cerevisiae* respectively. In the meantime, the HBS cultivated on bagasse show an increase in total counts and reached 62%, 118% and 190% with, *Ps. fluorescens*, *S. cerevisiae* and *Ps. fluorescens* + *S. cerevisiae* respectively. The vegetative characteristics and chemical analysis of HBS developed on the fine size of rice straw and bagasse that had been inoculated with *Pseudomonas* + *Saccharomyces* displayed the highest fresh weight.

Keywords: Agricultural residues, beneficial microorganisms, hydroponics sprouted barley, sprouted green fodder quality.

INTRODUCTION

Reducing agricultural water use while maintaining or improving economic productivity of the agricultural sector is a major challenge in arid and semiarid regions. Irrigated agricultural land is the major consumer of fresh water supplies in many parts of the world, particularly in relatively arid and semiarid regions like Egypt. The demand for scarce water resources in these countries is increasing with time for both agricultural and non-agricultural purposes (Al-Karaki, 2012 and Al-Hashimi, 2008).

Hydroponics is a system of agriculture whereby plants are grown without the use of traditional soil as a media. There are two advantages of the soil-less cultivation of plants, firstly, hydroponics may potentially produce much higher crop yields, and secondly, hydroponics can be used in places where in-ground agriculture or gardening is not possible.

A hydroponic technique can be used for green fodder production of many forage crops in a hygienic environment free of chemicals like insecticides, herbicides, fungicides, and artificial growth promoters (Al-Hashmi, 2008 and Al-Karaki and Al-Momani, 2018). It is a well-known technique for high fodder yield, year-round production and least water consumption (Tudor et al., 2003; Al-Karaki, 2012 and Al-Karaki and Al-Momani, 2018). Unlike field production system that uses run-to-waste irrigation practices, the hydroponic fodder system uses a recirculation system, thus reducing the wastewater. It has been reported that hydroponic fodder production requires only about 2-3% of that water used under field conditions to produce the same amount of

fodder (Al-Karaki and Al-Momani, 2018).

Fodder produced hydroponically is of a short growth period 7–10 days and does not require high-quality arable land, but only a small piece of land for production to take place (Mooney, 2005 and Al-Karaki, 2012). It is of high feed quality, rich with proteins, fiber, vitamins, and minerals (Lorenz, 1980; Bhise et al., 1988 and Chung et al., 1989).

All these special features of the hydroponic system, in addition to others, make it one of the most important agricultural techniques currently in use for green forage production in many countries especially in arid and semiarid regions of the world (Al-Karaki, 2012).

Sharma et al., (2014) reported that some rhizobacteria have been applied successfully to seed or soil to control soil diseases and enhance plant growth. Efficient Pseudomonas strains improve the result by suppressing pathogen inoculum, protecting the plant against infection, and improving the plant resistance against the pathogen (Hyakumachi, 2013).

Patten and Glick (2002) stated that some fluorescens pseudomonads having the ability to produce IAA and growth hormones. Khan et al. (2006) and Petti et al., (2010) reported that Pseudomonas fluorescens had the ability to induce local and systemic responses in wheat and barley tissue resulting in enhancing resistance to fungal diseases.

Barley grains are the most nutritious of the small grains and are easy to store or grow. Feed Your Farm, one of the companies supplying sprouting systems, has experimented extensively with wheat and oats but has found that barley sprouts the best, grow the fastest and is most cost-effective of all the grains tried. To work well for sprouted fodder, the barley grains need a high germination rate and must be very clean (Devender, 2016).

Barley (Hordeum vulgare) is a common crop for both animal and human diets. It is one of the most popular cereals. It is one of the oldest crops to be domesticated by man. It has been cultivated for over 8000 years (Zohary and Hopf, 2000). It is adaptable to most parts of the world from arctic to the tropics. Among the major barley growers and exporters include European Union, Australia, and Canada while the largest importers are Saudi Arabia (mainly as livestock feed), Japan (for food and malt production), and China (Taylor et al.,2005). Barley as a livestock feed was primarily used as a source of protein and energy in beef cattle diet. When the crop is properly processed, mixed, and fed it is an excellent feed. The processing of barley needs a lot of care in order to maximize digestion efficiency and maintain stable rumen functions mostly among the ruminants (NDSU, 2017).

Barley provides about 25% proteins, minimal labor needed. Barley has a lot of sugar hence provide a lot of energy. It uses 80% less water than growing fodder in the traditional soil. It is possible to control the nutrition levels in their entirety thus, lower nutrition requirements. No nutrition pollution is released into the environment because of the controlled system. Pests and diseases are easier to get rid of than in soil (Devender, 2016).

So, the objectives of this study were to evaluate forage crops barley (Hordeum vulgare) for green fodder production under hydroponic conditions by using agricultural residues and microorganisms.

MATERIALS AND METHODS

This study was conducted at the Hydroponics Laboratory, Department of Agricultural Engineering, Faculty of Agriculture, Cairo University.

Sprouting chamber and its environment

Sprouted green fodder production unit was locally designed and fabricated with dimensions of 4, 6 and 3 meters for width, length and height respectively. This unit contains three stands each of them divided into nine rows. Each row is designed to receive 16 trays with three dimensions of 30, 90 and 5 cm (Figure 1). As a result, the total production capacity of this unit is 432 trays per cycle (8 days). Automatic systems of irrigation, fertigation, ventilation, lighting, and air conditioning were installed inside the chamber (Hegab, 2017).

Operating the irrigation system on three programs should be used (the first is 60 second every 6 hours for the first three days, the second is 45 second every 8 hours for the second three days, and the last two days 30 second every 12 hours for the remainder days) for the best engineering management for the deficit water resources in the hydroponics sprouted barley grains production (Hegab, 2017).

Figure1: Hydroponic sprout chamber

Plastic trays with a length of 90 cm, a width of 30 cm, and a depth of 5 cm were used for growing seeds to produce green fodder. Through the production trials, air temperature, relative humidity, and lighting intensity were fixed at 20◦C, 75%, and 3600 Lux per Sq. meter respectively (Hegab, 2018).

Plant Material

Forage crop evaluates in this study was barley (*Hordeum vulgare*). Grains of this crop were obtained from the Field Crops Research Institute, Agricultural Research Center, Giza. Grains were subjected to stander germination test to check for their viability before being used.

The clean grains were washed well from residues of bleach. Then the cleaned grains were sterilized by soaking for 30 minutes in a 5% sodium hypochlorite solution (household bleach) to control the formation of mold. The cleaned grains were soaked in tap water for a period of (6 hours). Finally, the water was removed and the socked grains were composted for a period of 18 hours before planting on the agricultural residues (Hegab, 2018).

Microbial inoculation

The microbial strains (*Pseudomonas fluorescens* ATCC17397 and *Saccharomyces cerevisiae* ATCC 7754) used in inoculation treatment were obtained from the Agricultural Microbiology Department, Faculty of Agriculture, Cairo University.

Inoculant preparations

Each of the strain used in inoculation treatment was grown separately on nutrient broth and potato dextrose broth for 24 h at 30°C. The ml of each culture contains $1.1*10^7$ CFU ml^{-1}. Each tray takes 10 ml culture from each strain at zero time and repeated two times again at second and third day after cultivation.

Irrigation management

The barley grains were irrigated by tap water for first two days. From the third days, the sprouts were irrigated by Cooper nutrient solution (Cooper, 1988).

Fodder vegetation properties

Hydroponic barley sprout was terminated after 8 days from seeding, where the fodder biomass was ready for harvest (Figure 2). At harvest time, the following data were recorded per tray: total fresh and dry fodder yields as well as the shoot and root lengths. Representative fresh plant samples (about 100 grams) from every tray were taken at harvest, oven-dried at 500◦C for 48 hours, and weighed to compute the moisture content and dry weight.

Chemical analysis

Dry matter (DM), Crude protein (Cp), Crude fiber (Cf), and ash of sprouted and non-sprouted barley were determined in General Analysis Lab., Cairo University Research Park (CURP), Faculty of Agriculture, Cairo University.

Figure 2: Hydroponic Barley sprouts after 8 days of cultivation on agricultural residual with microbial inoculation.

The determination and detected methods used according to methods of Association of Official Analytical Chemists (A.O.A.C., 1989, 1990, 1995, and 2000). The nitrogen-free extract was calculated by subtracting the summation of DM, Cp, Cf, fat, and ash from 100 g. Total lipids was extracted using chloroform: methanol mixture as described by (AOAC, 2000). Total carbohydrate and soluble sugars were determined according to the methods of (Dubois, 1958).

Experimental design and statistical analysis

The completely randomized design (CRD) was used with five replicates. Data were statistically analyzed using analysis of variance (ANOVA) according to the statistical package MSTAT-C (Michigan State University, East Lansing, MI, USA, 1994). Probabilities of significance among treatments (crops) and LSD ($P \leq 0.05$) were used to compare means among treatments.

RESULTS AND DISCUSSION

Number of grains

A number of barley grains in 100 g were ranged between 2550 to 2620 grains Table (1). This test was carried out in order to know the number of grains in each tray.

Table 1: A number of barley grains in 100g and 1000 g grains.

Replication	Number of grains in	
	100 g	1000 g
1	2465	24650
2	2500	25000
3	2600	26000
4	2620	26200
5	2700	27000
Mean	2577	25770
LSD at 0.05	115	1170

Germination rate

The germination percent of 25 grains of barley and repeated 6 times was recorded after 24 hours of incubation at 25 ºC. The germination percentages reached 88% Table (2). This means that approximately all grain of barley can germinate during the growth period.

Table 2: The number of germinated barley and germination percent.

Replication	Germination grain number	Germination percent (%)
1	23	92
2	22	88
3	22	88
4	21	84
5	22	88
6	22	88
Mean	22	88
LSD at 0.05	2.95	7.56

Microbial determinations

In raw materials

The total bacterial and fungal counts were recorded in the agricultural residues (rice straw and bagasse) before used. Results obtained revealed that the microbial counts in rice straw were less than estimated in bagasse. Where the counts reached to $2.6*10^4$ CFU g^{-1} rice straw and the fungal counts to $1.4*10^2$ CFU g^{-1} rice straws. While in bagasse the counts were high and reached to $5.8*10^6$ CFU g^{-1} bagasse. In addition, the fungal counts reached to $3.0*10^4$cfu g^{-1} bagasse. Moreover, the microbial counts found in barley grains reached to $5.3*10^4$ CFU g^{-1} grain and the fungal counts reached to $1.6*10^3$ CFU g^{-1} grains Table (3).

Table 3 : The microbial and fungal counts recorded in rice straw, bagasse residual and barley grains.

Name of residual	TMC (*10^5)	TFC (* 10^3)
Rice straw	0.26	0.14
Bagasse	58.00	30.00
Barley Grain	0.53	1.60

TMC, total microbial count and TFC, total fungal count

Percent distribution in microbial count

The percent distribution of microbial community in both of rice straw and bagasse residual presented in (Fig.3). Almost, the microbial percent was approximating similar in both residuals except, spore-forming bacteria and yeast. Where the spore former percent was higher in rice straw (56%) than in bagasse (43%). While the yeast percent was lower in rice straw (6%) than in bagasse (18%).

In Hydroponic Barley Sprout (HBS)

The microbial count recorded in HBS during the growth period was recorded and presented in Table (4). In the beginning, the counts were depending on the type and length of agricultural residual used as well as the type of inoculation (single strain or mixed strain).

Data recorded revealed that in rice straw, the highest counts 2.8*10^4 CFU g^{-1} were estimated in fine size and the count decrease by increasing the residual length. The decrease reached to -57% and -85.7% in control medium and rough length. While with inoculation treatments, the figure was different *i.e.,* with *Ps. fluorescens* inoculation the counts increased with the increase of the growth period. Where the bacterial counts increase by +80% after 8 days from germination. But in the fungal count, it was decreased by -30.8% at the end of growth.

When mixing an inoculation of *Ps. fluorescens* plus *S. cerevisiae* the bacterial counts increased by 189.8% and the fungal counts decreased by -26% at the end of sprouted barley.

The obtained results were in agreement with the results reported by Karthikeyan et al., (2006) and Sharma et al., (2014). They reported that fluorescent pseudomonads could be used to manage plant diseases and as bio-fertilizers to crop plants. Also, Minaxi and Saxena (2010) stated that some of the fluorescent pseudomonads had been applied successfully to seed and soil to control soil diseases and enhance plant growth.

Moreover, El-Assiuty et al., (2010) emphasized that a positive relationship between chitinase production and the antifungal activity of *Pseudomonas* spp.

Values in parenthesis represent change percentages related to control. On the other hand, the counts estimated with bagasse residual as control treatment (without inoculation) were high at zero time 3.5*105 CFU g^{-1} and increased during the growth period reached to 9.8*105 CFU g^{-1} at the end of HBS growth period Table (5). While, with inoculation treatments (single or mixed) the bacterial counts were higher and reached to 5.0, 6.6 and 8.2* 10^5 CFU g^{-1} at zero time with *Ps. fluorescens*, *S. cerevisiae* and *Ps. Fluorescens* + *S. cerevisiae* respectively. Moreover, the counts increased by increasing the HBS growth period by 91.8%, 119.0%, and 172.2% depending on the same treatment applied as above mention.

On the other hand, fungi counts were low from the beginning and decreased during HBS growth period. The fungal counts were ranged between 110 to 130 colonies with rice straw and 280 to 340 with bagasse at zero time and decreased during the HBS growth period Table (5)

Vegetative qualities

The vegetative qualities of hydroponic barley sprout (HBS) were shown in Table (6). No significant difference was observed in all vegetative characters of HBS after 8 days of germination on rice straw or bagasse residual.

The fresh weight of HBS grown on rice straw data revealed that the best size of the agricultural residual is a fine size (≥1.0 cm^2), and the best treatment was composite inoculum (*Ps. fluorescens + S. cerevisiae)*. While the lowest fresh weight obtained was recorded with large length “Rough straw” (≥ 2.5*5.0 cm^2) especially with inoculation treatment single strain or mixed strain Table (6).

Also, in bagasse residual, the best straw was fine especially with inoculation with a single inoculum of *S. cerevisiae* (34.1 g) or with a composite inoculum (39.4g), respectively.The same picture was observed in dry weight whether in the case of the size of the agricultural residual or the type of inoculation Table (6). While in the shoot length the highest length recorded with rice straw and bagasse residual were 28.0 and 31.1cm after 8 days of HBS inoculated with the composite inoculum of *Ps. fluorescens* and *S. cerevisiae*.

Table 4: The microbial count (*10^5) and total fungal count (*10^2) estimated at grown on rice straw and bagasse during the HBS growth period.

Residual length	Treatment	The incubation period (days)					
		Zero		4		8	
		TMC	TFC	TMC	TFC	TMC	TFC
F	Control	0.28	1.10	0.36(+ 28.6)	1.00(-9.0)	0.49(+ 75)	0.60(- 45.5)
M		0.12(-57.0)	0.40(- 64)	0.13(+ 8.3)	0.41(+ 2.5)	0.15(+ 25.0)	0.30(- 25.0)
R		0.04(- 85.7)	0.10(- 91)	0.045(+12.5)	0.12(+ 25)	0.06(+ 25.0)	0.16(+ 60.0)
F	*Ps. fluorescens*	0.40(+ 42.9)	1.30(+18.2)	0.58(+ 38)	1.00(0)	0.72(+ 47)	0.90(+ 50)
M		0.26(- 8)	0.45(+ 13)	0.19(+ 46)	0.43(+ 1)	0.22(+ 47)	0.42(+ 40)
R		0.05(- 58)	0.10(0)	0.07(+ 56)	0.11(- 8)	0.09(+ 50)	0.09(- 44)
F	*S. cerevisiae*	0.42(+ 50)	1.3(+ 18)	0.70(+ 94)	1.60(+ 60)	0.92(+ 88)	1.50(+ 150)
M		0.17(+ 42)	0.47(+ 18)	0.21((+ 62)	0.53(+ 29)	0.33(+ 107)	0.50(+ 67)
R		0.055(+ 38)	0.10(0)	0.07(+ 27)	0.14(+ 17)	0.10(+ 67)	0.06(- 63)
F	*Ps. fluorescens +S. cerevisiae*	0.49((+ 75)	1.35(+ 23)	0.95(+ 94)	1.20(+ 20)	1.42(+190)	0.50(- 17)
M		0.18(+ 50)	0.48(+ 20)	0.24(33)	0.44(+ 7)	0.42(+ 180)	0.22(- 27)
R		0.06(+ 50)	0.11(+ 10)	0.09(50)	0.14(+ 17)	0.13(+ 117)	0.05(- 69)

Table 5: The microbial count (* 10^5) and total fungal count (*10^2) estimated at HBS during the Hydroponic Barley Sprout growth period.

Treatment	Residual length	Time (days)					
		Zero		4		8	
		TMC	TFC	TMC	TFC	TMC	TFC
Control	F	3.50	2.80	5.54 (+ 58)	3.00 (+ 7)	9.80 (+ 180)	3.10 (+ 11)
	M	1.30 (- 169)	1.60 (- 75)	2.02 (+ 55)	1.74 (+ 9)	3.34 (+ 157)	2.11 (+ 32)
	R	0.75 (-367)	1.10 (- 155)	0.92 (+ 23)	1.20 (+ 9)	1.74 (+ 132)	1.34 (+ 22)
Ps. fluorescens	F	5.00 (+ 42)	2.90 (+ 4)	7.70 (+ 39)	2.63 (- 12)	9.59 (+ 92)	2.32 (- 25)
	M	1.70 (+ 31)	1.62 (+ 1.3	2.46 (+ 22)	1.62 (- 7)	5.01 (+ 50)	1.64 (- 22)
	R	0.87 (+ 16)	1.11 (+ 0.9)	1.12 (+ 21)	1.10 (- 8)	2.27 (+ 30)	1.16 (- 13)
S. cerevisiae	F	6.62 (+ 89)	4.10 (+47)	11.14 (+ 101)	3.6 (+ 20)	14.50 (+ 119)	3.72 (+ 20)
	M	2.14 (+ 165)	1.69 (+ 6)	4.07 (+ 101)	1.84 (6)	6.36 (+ 90)	2.22 (+ 5)
	R	1.12 (+ 349)	1.16 (+6)	1.72 (+ 87)	1.23 (+ 3)	2.47 (+ 41)	1.40 (+ 5)
Ps. fluorescens* + *S. cerevisiae	F	8.23 (+135)	3.30 (+ 18)	19.40 (+ 251)	3.36 (+ 12)	22.40 (+ 172)	3.32 (+ 7)
	M	2.64 (+ 103)	1.97 (+ 23)	6.53 (+ 223)	1.86 (+ 7)	7.40 (+ 122)	2.21 (+ 5)
	R	1.34 (+ 79)	1.02 (- 7)	2.87 (+ 211)	1.26 (+ 5)	3.49 (+ 101)	1.33 (- 0.8)

TBC, total bacterial count; TFC, total fungi count,
Values in parenthesis represent change percentages related to control

Table 6: The fresh weight, dry weight and shoot and root length of sprout barley after 8 days of growth.

Residual	Treatment	Straw texture	Fresh weight (gm)	Dry weight (gm)	Shoot length (cm)	Root length (cm)
Rice straw	Control	Fine	29.7	1.4	19.4	4.0
		Medium	27.1	1.4	17.2	3.0
		Rough	25.8	1.3	14.1	2.0
	Ps. fluorescens	Fine	26.1	1.2	24.8	4.5
		Medium	23.1	1.2	20.4	3.3
		Large	21.2	1.2	17.0	2.3
	S. cerevisiae	Fine	27.9	1.3	24.0	5.2
		Medium	26.3	1.3	20.1	3.8
		Rough	22.6	1.2	16.0	2.8
	Ps. fluorescens + S. cerevisiae	Fine	36.8	1.6	28.0	5.5
		Medium	32.1	1.5	23.7	4.0
		Rough	28.6	1.4	17.9	3.0
Bagasse	*Control*	Fine	31.1	1.5	20.0	3.8
		Medium	24.2	1.3	17.3	3.0
		Rough	21.2	1.3	15.0	2.1
	Ps. fluorescens	Fine	26.7	1.4	25.0	3.9
		Medium	23.9	1.3	21.2	3.0
		Rough	21.7	1.2	19.1	2.2
	S. cerevisiae	Fine	34.1	1.5	23.0	4.6
		Medium	30.2	1.4	20.3	3.8
		Rough	24.8	1.3	18.0	3.0
	Ps. fluorescens + S. cerevisiae	Fine	39.4	1.8	31.1	6.8
		Medium	34.2	1.6	27.5	5.4
		Rough	28.2	1.5	20.1	3.1
L.S.D. at $P^{\leq 0.05}$			19.27	2.45	18.20	4.16

In addition, the highest root length recorded in both of rice straw or bagasse reached 5.5 and 6.8 cm after 8 days of HBS Table (6).

Chemical determinations

The results about HBS cultivated on different sizes of rice straw were recorded in Table (7). The data obtained revealed that the optimum length for HBS was a fine size (≥1 cm^2) for Ash, Lipid, Fiber and protein contents. While, in case of microbial inoculate, we found that *Ps. fluorescens* inoculation was more suitable of rice straw, where, its increased ash content by (5.3 %), total lipid (8.0%), and fiber content (31%) and protein content (4.5%), respectively.

The values of nitrogen-free extracts (NFE) were depending upon the texture of residual tested and type of microbial inoculation. In rice straw texture, the low NFE value was recorded in fine size (> 1.0 cm). But, in inoculum treatment, the NFE was low with *Ps. fluorescens*. (- 19%), *S. cerevisiae* (1.40%) and *Ps. fluorescens + S. cerevisiae* (12.5%), respectively.

The DM, in non-inoculated HBS, decreased through the growth period (8 days). The percent decrease was increased according to the rice straw size Table (8). Where the highest decrease percent was recorded with big size (5.0 cm) 13.9%. But, with microbial inoculation the percent decrease was less and ranged between 9.2 - 10.2% with *Ps. fluorescens*, 2.5 - 5.9% with *S. cerevisiae* and 6.0 - 8.0 with *Ps. fluorescens + S. cerevisiae,* respectively.

The decrease in DM content, which was mainly attributed to the inhibition of water and enzyme activities that depleted the food reserves of the seed endosperm (oxidation) without any adequate replenishment from photosynthesis by the young plant during short growing cycle (Sneath and Mclntosh, 2003).

In eight days sprout, photosynthesis commences around day five, when the chloroplast are activated and this does not provide enough time for any significant DM accumulation (Dung et al., 2010). The DM content decreased might also be due to the decrease in the starch content. During sprouting, starch is catabolized to soluble sugars for supporting the metabolism and energy requirement of the growing plants for respiration

and cell wall synthesis, so any decrease in amount in DM (Naik et al., 2015).

The results of total carbohydrate and soluble carbohydrate as presented in Table (8) indicated that the total carbohydrate content did not change between rice straw sizes. But, in cases of *Pseudomonas* spp. and *Saccharomyces* spp. inoculum, the content increased but in low percentage. The range was 2.8 to 5.4 % for *Pseudomonas* and 5.9 to 14.6 % respectively. While, the soluble sugars, the picture was different, the percentage was increased. The highly increased was reached to 38.7% increase in *Saccharomyces* spp. inoculum with fine size. Naik et al., (2015) recorded that, the increased in soluble carbohydrates may be due to starch content. Where, in barley sprouting, starch in catabolized to soluble sugars for supporting the metabolism and energy requirement of the growing plants for respiration and cell wall synthesis.

In bagasse residual, the values of ash, lipid, fiber, protein contents in un-inoculated ones were decreased depending on the length of bagasse Table (9). The decreased percentages reached 17% with Ash content, 43% with lipid content, 29.4% with fiber content and 23% with protein content respectively. Similarly, the decrease was recorded in inoculation treatments in spite of type of inoculation.

The percent increase in NFE reached 21.0 % and 32.0% when HBS germinated on medium and rough length, respectively. In inoculum treatment, the decrease reached 6.0% with *S. cerevisiae* and 2.8% with *Ps. fluorescens* and 4.5% with *Pseudomonas* + *Saccharomyces* compared with grains barley. Similar results were obtained by McCandlish and Struthers (1938), Thomas and Reddy (1962), Hillier and Perry (1969) and Trubey et al., (1969).

Table 7: The chemical constituents of 100 g HBS cultivated on the different texture of rice straw.

Treatments	Straw Texture	Ash	Lipid	Fiber	Protein	NFE
Control	**F**	9.08	4.39	23.64	15.88	47.01
	M	8.71	3.01	22.46	15.69	50.13
	R	6.48	1.95	21.72	14.88	54.96
Ps. Fluorescens	**F**	9.56	4.74	31.01	16.59	38.10
	M	6.99	3.56	24.31	15.78	48.36
	R	6.38	1.67	24.01	12.31	55.63
S. cerevisiae	**F**	7.34	4.55	26.02	15.75	46.34
	M	6.64	4.19	24.01	15.13	50.03
	R	5.67	2.46	16.81	12.78	57.78
Ps. fluorescens + S. cerevisiae	**F**	8.46	4.66	28.41	17.32	41.15
	M	7.26	4.19	23.98	15.02	49.53
	R	6.41	3.47	20.01	13.12	56.98
L.S.D. at $P^{\leq 0.05}$		4.6	1.5	5.4	4.8	7.2

Table 8: The chemical constituents of 100 gram HBS sprouted on rice straw with different textures.

Treat.	Straw Texture	DM (g)	Total carbohydrates (g)	Total soluble sugars (g)
Control	F	9.60	54.00	13.00
	M	8.70	54.00	12.90
	R	8.27	53.80	12.60
Ps. fluorescens	F	9.80	56.94	13.71
	M	8.90	55.98	13.65
	R	8.80	55.49	12.94
S. cerevisiae	F	9.51	46.11	17.20
	M	9.27	48.05	15.02
	R	8.95	50.80	12.57
Ps. fluorescens + S. cerevisiae	F	9.90	45.80	19.40
	M	9.30	48.00	16.80
	R	9.10	49.30	13.40
L.S.D. at $P^{\leq 0.05}$		4.70	7.40	5.30

Table 9: The chemical constituents of 100 gram HBS sprouted on bagasse straw with different textures.

Treat.	Straw texture	Ash (g)	Lipid (g)	Fiber (g)	Protein (g)	NFE (g)
Control	F	4.66	2.63	29.65	17.50	45.56
	M	4.26	2.02	22.67	15.97	55.08
	R	3.87	1.50	20.93	13.47	60.23
Ps. fluorescens.	F	4.77	4.39	30.64	13.91	44.29
	M	4.53	4.29	28.02	13.70	49.46
	R	3.78	3.43	23.63	13.75	55.41
S. cerevisiae.	F	5.62	4.25	30.51	16.78	42.84
	M	5.39	2.32	28.67	16.44	47.18
	R	4.34	2.14	23.69	14.69	55.14
Ps. fluorescens + S. cerevisiae	F	6.21	4.51	30.24	15.51	43.53
	M	5.74	4.20	28.10	15.20	46.76
	R	4.02	3.63	23.19	14.80	54.36
L.S.D. at $P^{\leq 0.05}$		1.1	1.6	6.6	5.8	7.9

Table 10: The chemical constituents of HBS sprouted on different sizes of bagasse.

Treatments	Straw texture	DM	Total carbohydrates	Total soluble sugars
Bagasse		13.4	62.0	14.4
Barley		91.4	64.7	3.8
Control	F	21.0	75.5	13.5
	M	24.2	75.7	11.4
	R	34.0	76.5	9.8
Ps. Fluorescens	F	17.6	77.0	12.3
	M	23.9	78.0	9.5
	R	26.7	78.3	9.0
S. cerevisiae	F	24.0	70.2	24.0
	M	30.2	75.8	15.6
	R	32.0	77.9	14.5
Ps. fluorescens .+ S. cerevisiae	F	25.0	60.1	31.0
	M	31.6	78.2	17.4
	R	34.4	78.6	15.0
L.S.D. at $P^{\leq 0.05}$		10.2	8.9	5.3

Dry matter content, total carbohydrate and total soluble carbohydrate contents estimated in HBS sprouted on bagasse were found in Table (10).

DM results obtained showed a significant difference between its content in bagasse residual and barley grain. Where it was 13.4% in bagasse residual and 91.4% in barley grain. While in the DM content of HBS was reduced by decreasing the length of residual used.

The quantity of fresh HBS obtained per 500 g barley grain (tray) was 15 times grain. This increase was due to the large uptake of water during germination of the grains. This action led to a sharply reduced in DM percentage in HBS. Our results were in accordance with those of Bautisia (2002) and Morgan et al., (1992) with the inoculation treatments, single or mixed; the figure approximately was the same.

In addition, the total carbohydrate results showed no significant difference were found between bagasse residual and barley grain or between HBS inoculated with single or mixed strain and un-inoculated ones. In the case of, water-soluble carbohydrate (WSC) was increased in HBS compared to the barley grain or between un-inoculated or inoculated ones with *Pseudomonas* spp. and inoculated with *Saccharomyces* or mixed inoculum During the barley sprouting, the organic matter especially starch was consumed to support metabolism and energy requirement of the growth (Chavan and Kadam, 1989).

CONCLUSION

The results concluded that the best residual

used for HBS was the rice straw or bagasse, the best residual length was fine length (≥ 1.0 cm^2), the best treatment was a mixed inoculation of *Ps. fluorescens* and *S. cerevisiae* and the best time for production was 8 days.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

REFERENCES

Al-Assiuty, E. M.; Rizk, M. A. and Ibrahium, A. E. (2010). Changes in nutrient contents and protein induction in *Cercospora beticola* infected sugar beet plants in relation to treatments of some bio-agents. *Egypt J. Appl. Sci.,* 25 (8): 326-330.

Al-Hashmi, M. M. (2008). Hydroponic green fodder production in the Arabian Gulf Region, M.S. thesis, Faculty of Graduate Studies, Arabian Gulf University, Manama, Bahrain, 110 P.

Al-Karaki, G. N and Al-Momani, N. (2018). Evaluation of some barley cultivars for green fodder production and water use efficiency under hydroponic conditions," *Jordan Journal of Agricultural Sciences*.

Al-Karaki, G. N. (2012).Utilization of treated wastewater for green forage production in a hydroponic system, *Emirates Journal of Food and Agriculture*, 23: 80–94.

AOAC (1989) Official Methods of Analysis. 14th Edition, Association of Official Analytical Chemists, Washington DC. 615P.

AOAC, (1990). Official Methods of Analysis, 15.th Edition Association of Official Analytical Chemists, Arlington, 860P.

AOAC. (1995). Official methods of analysis 16th Eds. Association of official analytical chemists. Washington DC, USA. 720P.

AOAC. (2000) Official methods of analysis of AOAC. International 17th edition; Gaithersburg, MD, USA Association of Analytical Communities. 816 P.

Bautista, S.H. (2002). Producción de forraje verde hidropónico de trigo *Triticum aestivum* L. para el mantenimiento de conejos criollos Oryctolagus cuniculus. MSc thesis, Universidad Autónoma de Guerrero (UAG) Chilpancingo, Guerrero, México. 156 p.

Bhise, V. Chavan, J. and Kadam, S. (1988). Effects of malting on proximate composition and in vitro protein and starch digestibilities of grain sorghum," *Journal of Food Science and Technology,* 25(6): 327–329.

Chavan, J.K., and Kadam, S.S. (1989). Nutritional improvement of cereals by sprouting. *Rev. Food Sci. Nutr*. 28(5):401-437.

Chung, T. Y. Nwokolo, E. N. and Sim, J. S. (1989). Compositional and digestibility changes in sprouted barley and canola seeds, *Plant Foods for Human Nutrition*, 39(3): 267–278.

Cooper, A. (1988). 1. The system. 2. Operation of the System. In: The ABC of NFT. Nutrient Film Technique, pp. 3-123, Grower Books (Ends). London, England.

Devender, R. (2016). Development of feeding system based on hydroponic barley fodder for sheep. M.Sc. Thesis. SRI P. V. *Rao Telangana State University for Veterinary*, 2018 P.

DuBois, Michel. Gilles, K. A., Hamilton, J. K., Rebers, P. A., and Fred. Smith. (1958). Colorimetric Method for Determination of Sugars and Related Substances *Anal. Chem.*, *28* (3): 350–356.

Dung, D. D.; Godwin, I. R.; Nolan, J. V. (2010). Nutrient content and *in Sacco* digestibility of barley grain and sprouted barley. *J. Anim. Vet. Adv.,* 9 (19): 2485-2492

Hegab, K. K. (2017). Successive management programs for the deficit water resources in hydroponics and soilless green fodder production, *Misr J. Ag. Eng*., 34 (4-1): 1869 – 1896

Hegab, K. K. (2018) Light uniformity improvement inside the sprouting environment and product evaluation, *Misr J. Ag. Eng.,* 35 (2):743-766.

Hillier, R. J., and Perry, T. W. (1969). Effect of hydroponically produced oat grass on ration digestibility of cattle. *J. of Animal Science*. 29:783-785.

Hyakumachi, M. (2013). Research on biological control of plant diseases: Present state and perspectives. *J. Gen. Plant Pathol.,* 79:435-440.

Jensen, M. H., and Malter, A. J. (1995). Protected agriculture: a global review," World Bank Technical Paper 253:17-29.

K.; Fu, J.; Zhang, X.; Fristensky, B.; Sparling, R. and Levin, D. B. (2014). Genome features of Pseudomonas putida LS46, a novel polyhydroxy alkanoate producer and its comparison with other P. putida strains. *AMB Express*. 4(37):1-18.

Karthikeyan, M.S.; Prasad, D. J.; Poojary, B.; Bhat, K. S.; Holla, B.S. and Kumari, N. S. (2006). Synthesis and biological activity of Schiff and Mannich bases bearing 2, 4-dichlo-5-fluorophenyl moiety. *Bioorganic and Medicinal Chemistry*. 14 (22):7482-7489.

Khan, M. R.; Fischer, S.; Egan, D. and Doohan, F. M. (2006). Biological control of *Fusarium* seedling blight disease of wheat and barley. *Phytopathology*. 96(4):386-394.

Lorenz, K. (1980). Cereal sprouts: composition, nutritive value, food applications, Critical Reviews in Food Science and Nutrition, 13 (4): 353–385,

McCandish, A.C. and Struthers, J. R. (1938). The influence of sprouted grain on digestibility. Scot. J. Agr., 21:141-149.

Minaxi, M. and Saxena, J. (2010). Characterization of *Pseudomonas aeruginosa* RM-3 as a potential biocontrol agent. *Mycopathologia*. 170:181-193.

Mooney, J. (2005).Growing cattle feed hydroponically," Meat and Livestock Australia. Commensal dendritic cell interaction specifies a unique protective skin immune signature. *Nature*. 520:104-109.

Morgan J, Hunter R R and O'Haire R. (1992). Limiting Factors in hydroponic barley grass production. 8th International Congress on Soilless Culture. Hunter's Rest; South Africa.

MSTATC (1994). Department of Crop and Soil Sciences Michigan State University East Lansing, MI 48824 USA.

Naik, P.K., Swain, B.K., and Singh, N.P. ((2015). Production and utilization of hydroponic fodder. *Indian J. Anim. Nut.,* 32(1):1-9.

NDSU, (2017). Barley grain and forage for beef cattle. North Dakota Agricultural Experiment Station Report. September 2017. 28 P.

Patten, C. L., and Glick, B. R. (2002). Role of *Pseudomonas putida* indo lactic acid in development of the host plant root system. *App. Environ. Microbial*, 68:3795-3801.

Petti, C.; Khan, M. and Doohan, F. (2010). Lipid transfer protein and protease inhibitors as key factors in the priming of barley responses to *Fusarium* head blight disease by a biocontrol strain of *Pseudomonas fluorescens*. Funct. Integ. Genomics., 10(4):619-627.

Sharma, p. k.; Fu, J; Zhang, X.; Fristensky, B.; Sparling, R. and Levin, D.B. (2014). Genome feature of *Pseudomonas putida* LS46, a novel polyhydroxy alkanoate and its comparison with other *P. putida* strains. *AMB Express*. 4(37): 1-18.

Sneath, R. and McIntosh, F. (2003). Review of Hydroponic Fodder Production for Beef Cattle. Department of Primary Industries: Queensland Australia 84. McKeehen, p. 54-56.

Taylor, R., Kebaara, B. W., Nazarenus, T., Jones, A., Yamanaka, R., Rachel Uhrenholdt,Jason P. Wendler, and Audrey L. Atkin* (2005). Gene set coregulated by the *Saccharomyces cerevisiae* nonsense-mediated mRNA decay pathway. *Eukaryot Cell*. 4(12):2066-77.

Thomas, J.W. and Reddy, B.S. (1962). Sprouted Oats as a Feed for Dairy Cows. Quarterly Bulletin of the Michigan *Agricultural Experiment Station*, 44: 654-655.

Trubey, C.R.M., Rhykerd, C.L., Noller, C.H., Ford, D.R. and George, J.R., (1969). Effect of light, culture solution, and growth period on growth and chemical composition of hydroponically produced oat seedlings. *Agron. J.,* 61: 663--665.

Tudor, G. Darcy, T. Smith, P. and Shallcross, F. (2003). The intake and live weight change of drought master steer fed hydroponically grown, young sprouted barley fodder (Autograss), Department of Agriculture Western Australia p.44-47.

Zohary, D and Hopf, M. (2000). Domestication of plants in the Old World. 3rd ed. 316 pp.