Increasing High Quality Homegrown Feeds for the Organic Dairy Fact Sheet Series

Literature Review: Hydroponically Sprouted Grains Systems on Organic Dairy Farms


Incomplete reference. But abstract says: A series of experiments were conducted to evaluate barley fodder (BF) as a feed for ruminants. Barley seeds were grown in a specially designed and controlled environment cabin at 15 - 18°C. The first experiment was conducted to germinate barley seeds from day 0 (d0) to day 10 (d10, n=II) and samples were collected daily for chemical composition analysis. In the second experiment, the rumen simulation technique (RUSITEC) was used to measure the in vitro dry matter (DM) and crude protein (CP) digestibility and the volatile fatty acids (VFA) produced by BF at different times. The nylon bag technique was also used to measure the DM degradability of BF in the rumen of cattle at 2,4,8, 12,24 and 48 hours. The third experiment involved the measurement of rumen fluid parameters (pH, ammonia and VF A) in three rumen fistulated bucks that were fed on eight-day old BF ad libitum. The CP, organic matter (OM), ether extract (EE), neutral detergent fibre (NDF), acid detergent fibre (ADF) and crude fibre (CF) contents of BF from d1 to d10 increased, but the DM content decreased with the age of BF. DM content at d7 and d8 were 1.5 and 1.3% while CP content were 1.2 and 1.3% respectively. The amount of calcium (Ca), phosphorus (P) and Nitrate (NO3) did not change significantly throughout sprouting time. In the in vivo, in vitro and in sacco DM degradability studies showed that 80 to 100% DM loss for BF harvested on d7 to d28. DM intake was lower in the third experiment although digestion coefficient (DC) of BF was very high (98%). This condition was probably due to the abnormal growth of BF during the experimental period. Rumen fluid pH was 5.9-6.0 and ammonia-N (NH3-N) content was 7.0 to 8.8 mg/mL. Total fatty acids production was 70 to 100 mmoVL between two and eight hour of collection. The acetic:propionic:butyric ratios were 58:36: 1.3, 68:25:2, 61:35:1.2, 64:33:0.7 and 65:32:1 at 0, 2, 4, 6 and 8 hours, respectively. Overall results showed that VFA and ammonia-nitrogen (NH3-N) were produced at a minimum level when BF was given ad libitum allowing the digestibility was higher in both in sacco and in vitro studies. BF should be given at different levels in order to get optimum pH, VFA and NH3-N production.


Abstract: In this study aimed that the effects of different harvesting times on the nutritional value of barley fodder producing in hydroponic system. Barley fodders were harvested on the 4th, 7th, 10th and 13th days following sowing date. Analysis performed for determining the chemical composition and organic matter digestibility (OMD) and ME content with in vitro gas production technique. It was determined that the DM content was decreased, the CP content was not changed significantly, cell wall contents (NDF, ADF, ADL) and ash content were increased by the maturation of the sprouts. In this study DM, ADF and ash contents were changed significantly (P<0.05). It was obtained that 96 hours cumulative gas production, OMD and ME contents were decreased by the increasing number of harvesting time but the variations were not significant (P>0.05). According to the results, suitable harvesting date was 7th day following the sowing in term of nutritional value of the fodder.

The authors expect climate change to negatively affect pasture production because of lack in rainfall in Turkey and therefore look at fodder systems as a way to maximize water efficiency in forage production (suggest that water use in fodder is 2 to 3% lower than field). They cite pro: “bio-chemical reactions [that] occur in seeds” and con: dry matter loss and high moisture content of fodder. Their system uses 75 F, 3000 lux light, irrigation 4x/day at 50 litres (13 gallons) per day. Used Slodoran barley variety at 0.416 kg (0.92 #) per tray. Study looked at harvest dates on nutritional value — harvested on day 4, 7, 10, and 13. Decrease in DM but no significant changes in CP. Ash content increased over time. Did see a numerical drop in

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OMD: organic matter digestibility and ME: metabolizable energy but was not statistically significant. Concluded that day 7 is best for harvest.


Abstract: Water shortage is considered the most important obstacle to the development of the agricultural sector in arid and semi-arid regions like Jordan. Therefore, looking for agricultural techniques that use water more efficiently is needed. An experiment has been conducted during March 2010 to evaluate three barley cultivars (ACSAD176, Rum, and local cultivar) for green fodder production, quality, and water use efficiency under hydroponic conditions. The results of this study showed that barley forage can be produced in 10 days from planting to harvest in the hydroponic system. The local cultivar was superior to the other two tested cultivars in respect to green and dry fodder yields, plant height, and conversion factor of seeds into green fodder. Green barley forage yields obtained were 222, 236 and 281 tons/ha [that means a total possible yields of 5500, 5900 and 7000 tons/ha/year can be achieved (with 25 harvests per year)] for ACSAD176, Rum, and local cultivar, respectively. This is more than 110, 118 and 140 times greater than the green yield obtained from conventional field grown alfalfa forage of 50 tons/ha/year. Moreover, the local cultivar used water more efficiently to produce green fodder than other cultivars (1.48 for local cultivar vs. 1.76 and 1.87 m3/ton for Rum and ACSAD176, respectively). This is a tremendous improvement in water use efficiency compared to 83 m3/ton produced under field conditions. Results also showed that hydroponic fodder of local cultivar was superior to field grown forages in respect to contents of crude protein, N, P, Mg, and Zn. In conclusion, local barley cultivar is the best choice for high production and quality of hydroponic green fodder with less water consumption. These findings are considered very important as seeds of this cultivar are mostly available in the market at lower price than others which reduce the cost of hydroponic fodder production.

Jordan uses 63% of its water for irrigating agricultural crops, has experienced severe feed shortages due to droughts and shortages of water for irrigation, and anticipates increasing demand for water for both ag and non-ag purposes. “The major constraints on livestock production in Jordan and many other countries in the Arabian region are the inadequate quantities and poor quality of the produced forage (e.g. green forage) in addition to the high cost of imported feed...local production of forage crops in Jordan covers only about 20-25% of its livestock feed requirements.” The authors cite, “It has been reported that about 1.5 to 2 liters of water (0.4 to 0.5 gallons) are needed to produce 1 kg (2.2 pounds) of green fodder hydroponically in comparison to 73 (19 gal), 85 (22.5 gal), and 160 liters (42 gal) to produce 1 kg of green fodder of barley, alfalfa, and Rhodes grass under field conditions, respectively. Mold controlled by soaking seeds in 20% bleach solution for 30 minutes—should check with your certifier about what to use.

Research showed that the “local cultivar,” a mix of local landraces performed best.


Abstract: The objectives of this study were to evaluate five forage crops (alfalfa (Medicago sativa), barley (Hordeum vulgare), cowpea (Vigna unguiculata), sorghum (Sorghum bicolor), and wheat (Triticum aestivum)) for green fodder production and water use efficiency under hydroponic conditions. The experiment has been conducted under temperature-controlled conditions (24 ± 1°C) and natural window illumination at growth room of Soilless Culture Laboratory, Arabian Gulf University, Manama, Bahrain. The results showed that green forage can be produced in 8 days from planting to harvest using hydroponic technique. Highest values for green fresh yields were recorded for the crops cowpea, barley, and alfalfa which gave 217, 200, and 194 tons/ha, respectively. However, only cowpea and barley crops gave the highest green dry yield, but not alfalfa. Barley crop used water more efficiently than the other four tested crops when produced about 654 kg fresh matter/m3 water in comparison to 633, 585, 552, and 521 kg fresh matter/m3 water for cowpea, sorghum, wheat, and alfalfa, respectively. No significant differences between barley and cowpea for water use efficiency were noted. It can be concluded from this study that barley crop can be considered the best choice for production of hydroponic green fodder with less water consumption.

Barley had best efficiency in terms of water use, plus seed was more affordable so total costs may be lower than other seed options.


Short article on reminders about fodder including: a) don’t purchase seed that has been heat-dried; b) fodder grown for 6-7 days. Benefits include: moderation of rumen pH (as compared to grain); enzymes break down starch into sugars, proteins into amino acids, and lipids into free fatty acids. Farmer using it on 150-head dairy in NY claims increases feed efficiency—from 55 # DM to 70#. A referenced article included that the farmer saw less heel warts and increased pregnancy rates due to reducing dietary starch according to farmer. The article noted that the switch to fodder resulted in an 80 # per cow per day drop in production but grain was reduced from 28 to 8 #.
This article profiles CA dairy farmer Bill Van Ryn who was the first producer to use Fodder Solutions for his feed. He claims that sprouts are 82% more digestible than grain; and experienced health vigor in some of his cattle. Water concentration figures used in the article include 750 gallons per ton for sprouts vs 180,000 to 360,000 gallons per ton (not clear what this feedstock is). His grain price (2009) was $500 per ton barley.


Abstract: A hydroponic nutrient solution was used to raise barley sprouts to compare with sprouts raised using tap water irrigation (two treatments). In both treatments, the sprouts were raised in continuous light in a temperature-controlled room for a period of 7 days. There was no difference (p>0.05) in DM loss after 7 days of sprouting. The DM losses after 7 days of sprouting were 16.4% vs. 13.3% for tap water irrigation and hydroponic nutrient solution, respectively. Sprouts grown with nutrient solution had a higher protein concentration than those grown with tap water irrigation (17.3 vs. 15.9%), respectively. There was however, no difference (p>0.05) in in sacco degradation of sprouts in the rumen of Merino sheep. There was no advantage in the use of nutrient solution for producing hydroponic sprouts compared to sprouting with tap water only. If these sprouts were fed to ruminants, the DM losses would have represented a loss in digestible energy which would otherwise have been available for productive purposes. On a large scale these losses could add to the cost of animal production. Crude protein and ash increased with both sprout treatments. Explanation for DM loss: seed soaking activates enzymes and essentially converts starch stored in endosperm to simple sugar which produces energy and gives off carbon dioxide and water, aka respiration – the loss of carbon dioxide leads to loss of DM (since little photosynthesis, cannot counteract loss).


Abstract: The studies reported in this research examined the nutrient profile of barley grain when it was sprouted hydroponically. Following sprouting, the measurement of animal response at experimental level and also in a commercial setting was performed in order to test the hypothesis that sprouting gives rise to hydroponic sprouts that give higher animal responses. In first part of the experiment, barley grain was sprouted hydroponically for a duration of 7 days. Daily sampling of the sprouts was done to assess DM concentration and also to determine the nutrient concentration on day 7 in comparison to the unsprouted grain. Results showed a 21.9% loss in DM from the original seed after sprouting for a period of 7 days. A loss of 2% GE was recorded after comparing the sprouts with the original grain. The CP, ash and all other minerals except potassium were lower in concentration on a DM basis in the barley grain than in the sprouts. This was considered to be a reflection of a loss in DM after sprouting causing a shift in concentration of these nutrients. The second phase of the experiment involved in sacco degradation of hydroponic barley sprouts and the unsprouted grain in the rumen of Merino sheep. There was no significant difference (p>0.05) in in sacco degradation when unsprouted grain was compared with hydroponic barley sprouts. It was concluded that the loss of 21% DM followed by a lack of difference in in sacco degradability disproved the presence of any advantage of sprouts over the original grain.


Farmer Linda DuShane sought a SARE grant to compare hydroponically produced sprouts to equivalent organic foodstuffs and non-organic foodstuffs during the course of project, including calculating costs of seeds used in the fodder system, their weight at time of harvest (after about one week), their sufficiency as food for the goats, and the need for any other type of food – such
as hay – to satisfy the hunger needs of the animals once the hydroponically produced fodder is their main foodstuff. Though the project is ongoing, an annual report revealed that $1000 spent on equipment and materials; $2750 on labor within a year. Their system uses a mixture of non-GMO wheat, soybean and black oil sunflower seeds, harvested at 10 inches of growth at about 8 to 10 days. They are able to feed 35 pounds per day (hoping to increase to 100 pounds). They did experience some difficulty maintaining adequate heat levels during Illinois winters, had issues with mold and pest but now soak seed in a 60% hydrogen peroxide solution prior to spraying.


Abstract: Animal production and its industrial investment are overwhelmed with various problems due to the insufficient animal feeding requirements and the competition with the human crop requirements. Therefore, about third of the total cultivated area of the world is covered with the animal feeding crops. In this regard, efforts have to be carried out to develop new techniques to face this competition. The aims of this study are to: 1) establish a hydroponic unit for intensive grass fodder production; 2) study the engineering parameters affecting the efficiency of the suggested unit such as light intensity and duration of aeration, nutrient solution and its characteristics and applied amounts of water, and 3) determine the total energy requirements for improving the unit production capacity. Therefore, a closed hydroponic system was established at the Central Lab. of Agric. Eng. Agric. Eng. Dept., Faculty of Agric., Ain Shams Univ., to achieve the abovementioned objectives. However, experimental layout included lighting system to provide plants with its lighting requirement, cooling and air conditioning unit to conserve the appropriate microclimate conditional to propagate a healthy plants and equipment, aeration and CO2 proportioning system, to enhance the root-zone media with its air balance and requirements to avoid the plant stress. Treatments of the affecting parameters could be summarized as follows: a- Engineering factors: 1) lighting time (8, 12, 16, and 24 h/day) with a fixed intensity of about 2021 lux, 2) aeration (36, 60, and 84 min/day), and 3) irrigation period (1, 2, and 3min/2h). Results of the hydroponics barley-grass fodder production under different treatments could be summarized as following: a1- The optimum lighting operating hours (2000 lux in intensity) for barley fodder production under the suggested hydroponic system was about 12-16 hours is the most suitable for fodder production of barley, and the vegetative growth. a2- Aeration time had a significant effect on the barley–production under the suggested hydroponics. However, there was a positive proportional relationship with all studied parameters, indicators and the aeration flow rate in terms of operating time. So, the best aeration flow rate was 3min/2h per day. b- Energy requirement: the total energy consumption for barley production under closed hydroponics systems was about 138 W/h. They also suggested that the total cost for barley production under closed and controlled hydroponics systems was about 4L.E/day 9 [$0.51 USD per day]. However, to produce 10.39 kg/day [22.9 pounds/day] fresh green in area 1m2 [10.8 sq ft], and one kilogram [2.2 pounds] from fresh green will cost 1L.E. [$0.13...6 cents/lb] so the net profit will be 6.39 L.E/day [$0.82 per day].


Abstract: Barley grain was sprouted in a still hydroponic growing chamber for 6, 7 and 8 day periods and sampled for chemical analyses, protein fractions, in vitro digestion and metabolisable energy (ME) determination. Productivity measured on the basis of the input-output balance of barley grain and GF yield. Results showed that CP, Ash, EE, NFC, ADF and water soluble carbohydrate (WSC) were increased whereas OM and non fiber carbohydrate (NFC) decreased (p<0.05) in the GF when compared with the original grain. As the growing period extended from day 6 to day 8, the CP, Ash, EE, NFC and ADF were increased but NFC and WSC reduced (p<0.05). The non protein nitrogen was increased but true protein decreased (p<0.05) in GF in comparison to barley grain, however no differences was shown among the growing periods for protein fractions. The potential (b) and rate (c) of in vitro gas production shown a decreasing trend (p<0.05) by sprouting the barley grain up to 8 days. The amount of OM and ME of GF, obtained per kg of cultivated barley grain, were lower than those of the original grain. Breakdown of complex compounds into simple form makes fodder highly digestible. Previous studies suggest that sprouting increases enzyme activity, increased total protein and changes in amino acid profile, increased sugars, crude fiber, certain vitamins and minerals, but decreased starch and loss of total dry matter. Green fodder production particularly important in regions where there is a limitation of forage and drought disaster. Their study found a significant decrease in DM (by increasing growing period from 6 to 7 days); ash content increased; ether extract increased; crude protein increased; NFC increased; ADF really increased; water soluble carbohydrates increased; CA increased; Fe and Zn increased. All they attribute to loss of DM and concentration of nutrients. Ca, K, P and Mg differences likely due to irrigation water and nutrient solutions.

It is concluded that no increase in quantity and quality of DM and nutrients could be obtained by sprouting barley grain still some DM and DOM loss was found in green fodder, therefore economically it is not recommended for animal farming.

Abstract: This experiment was conducted to evaluate the effect of barley green fodder produced by hydroponics system on the performance of feedlot calves. In a completely block randomized experiment, 24 cross bred (Holstein×Local) male calves were assigned randomly to one of the two treatments (diets) that were either control (grain barley) or hydroponic barley green fodder (BGF) that was included to provide 22.8 percent of the total diet on dry matter basis. Seed grade barley was grown in a hydroponics chamber system where the growth period was adjusted for 6 days. Body weight gain was not significantly different between the treatments, but the animals that had received the control diet had higher (P< 0.05) dry matter intake than those fed BGF diet. There was a tendency (P= 0.199) toward differences in feed efficiency due to dietary treatments. From economical point of view, feed cost increased up to 24 percent when the calves were offered BGF, because of the costly production of hydroponics green forage. Although the mass production of fresh fodder was about 4.5 times per kg of barley grain, this was due to water absorption during germination and growth period. Nevertheless, the dry matter obtained was less than the initial barley grain and further dry matter losses were found in the green fodder. These findings suggest that green fodder had no advantage over barley grain in feedlot calves, while it increased the cost of feed.

No advantage of fodder on weight gain; 24% increase in feed cost. Significant increase in CP (although they say non-protein N vs true protein) with fodder. Crude protein, neutral detergent fiber (NDF), acid detergent fiber (ADF) and Ca increased, but non-fiber carbohydrates (NFC) decreased in the green fodder compared to the barley grain on a DM basis. We expected that feeding vitamin-rich green forage that could activate some enzymes (during sprouting) and change the starch, protein, and lipids into simpler forms, might affect the animals performance; however, BGF probably did not have higher bioavailability of nutrients for fattening the calves in this experiment.

**Finney P L. 1982.** Effect of germination on cereal and legume nutrient changes and food or feed value. A comprehensive review. *Recent Advances in Phytochemistry* 17: 229–305.

Introduction: Cereals and legumes are the foodstuffs for most humans and animals and have been throughout recorded history. To extract “maximum nutrients for minimum costs,” the seeds of those plants have usually been treated by germinating, fermenting or selectively heat treating to increase the amount or availability of nutrients. In the so-called Western and highly industrial world the practice of sprouting is largely limited to malting cereals for the brewing industry; but for hundreds of millions of other world citizens sprouting of legumes and some cereals is routine in converting feed grains into human foods. However, for the past century researchers in both the Western and Eastern-world have studied the effects of germination on the physical, physiological, biochemical, nutritional, and food functional properties of cereals and legumes. This chapter brings together data from those studies and evaluates the ancient practice of sprouting seeds for food and feed uses from a contemporary viewpoint. Consolidation of this information about seed sprouting from numerous disciplines provides a view of the role that germination studies have played in the evolution of biological chemistry and how intimately interrelated it is with food science and nutrition.

This piece details nutritional factors of sprouted grains. For example, the author cites research and historical evidence of antiscorbutic properties (vit C) in barley and other sprouted grains as well as legumes. Studies suggest that antiscorbutic properties are related to those grains sprouted in sunlight. Water soluble B vitamin may increase in sprouts; thiamin increased after day 3 of sprouting in a number of studies. Riboflavin levels also increased in sprouts vs original grains. “In addition to hydrolyzing the bound form of niacin, the germination process invariably promotes increases in total niacin.”

**Fysken, J. 2014.** Adams Dairy sprouts new barley fodder venture. *Agri-View, Madison, WI.*

Farm publication article that describes 500-head organic dairy operation and their use of fodder. Has a FodderTek system that uses a 7-day cycle in a converted barn 72 x 100 temperature controlled (70 degrees year year); uses fodder as a grain and molasses replacement. 7 pounds of seed per 16” x 6’ trays yield about 45 pounds of fodder. On day 7, fodder is 6 to 8 inches tall. Fresh cow ration changed to reduce protein by 1 pound, reduce 1 pound haylage, and 2 # corn – added 3.4 pounds DM from fodder. Sprouts make up about 14% of TMR. His sprouts are 18% protein, 80% digestible. Sprout house cost $300,000 (no mention of labor, seed, etc.)

**Graze. 2013.** Fodder interest sprouting all over. *Graze Magazine 1 Jan 2013.*


Lay publication which give an excellent overview of fodder, its pros and cons, and describes how little research has been conducted on fodder systems in recent years. The article talks about how high grain and other forage prices are helping drive farmers to consider fodder. Interview with John Stoltzfus revealed that he has seen increased herd health and butterfat tests on his 80 cow organic herd; says it was a $5000 investment (not clear what this included); says he may be able to reduce MUNs to 12 and claims that his animals get more energy from fodder than pasture. An Australian publication claims that fodder is 2 to 5
more expensive than grain. Cites Jerry Brunetti who say fodder “removes much of the grain starch that can lead to overly acidic conditions in the rumen” and is highly digestible.


Abstract: A 4-unit dual-flow continuous-culture fermentor system was used to assess the effect of supplementing 7-d sprouted barley (SB) or barley grain (BG) with an herbage-based or haylage-based diet on nutrient digestibility, volatile fatty acid (VFA) profiles, bacterial protein synthesis, and methane (CH4) output. Treatments were randomly assigned to fermentors in a 4 × 4 Latin square design with a 2 × 2 factorial arrangement using 7 d for diet adaptation and 3 d for sample collection. Experimental diets were (1) 55.5 g of herbage dry matter (DM) + 4.5 g of SB DM, (2) 56.0 g of herbage DM + 4.0 g of BG DM, (3) 55.5 g of haylage DM + 4.5 g of SB DM, and (4) 56.0 g of haylage DM + 4.0 g of BG DM. Forages were fed at 0730, 1030, 1400, and 1900 h, whereas SB and BG were fed at 0730 and 1400 h. Gas samples for CH4 analysis were collected at 0725, 0900, 1000, 1355, 1530, and 1630 h on d 8, 9, and 10. Fluid samples were taken once daily on d 8, 9, and 10 for pH measurements and for ammonia-N and VFA analysis and analyzed for DM, organic matter, crude protein, neutral detergent fiber, and acid detergent fiber for determination of nutrient digestibilities and estimation of bacterial protein synthesis. Orthogonal contrasts were used to compare the effect of forage source (haylage vs. herbage), supplement (BG vs. SB), and the forage × supplement interaction. Apparent and true DM and organic matter digestibilities as well as apparent crude protein digestibility were not affected by forage source. However, true DM digestibility was greatest for diets supplemented with SB. Apparent neutral and acid detergent fiber digestibilities of herbage-based diets were higher than haylage-based diets but fiber digestibility was not affected by supplement. Diets supplemented with SB had higher mean and minimum pH than BG; however, maximum pH was not affected by diet. Supplementation with BG produced a greater concentration of total VFA compared with diets supplemented with SB. Haylage-based diets produced greater CH4 output compared with herbage-based diets but supplementation did not affect CH4 output. Efficiency of bacterial protein synthesis was greater for herbage-based diets compared with haylage-based diets, with no effect of supplementation. Overall, supplementation with SB marginally increased true DM digestibility of herbage- and haylage-based diets but did not affect fiber and crude protein digestibilities, CH4 output, and bacterial efficiency, compared with BG.

Some studies have reported DM losses ranging from 9.4 to 18% with sprouting. The loss of DM yield with sprouting, coupled with the slight numeric decrease in NEL, would result in a decrease of net available energy for the animal. Supplementation of SB increased DM digestibilities.

Proponents of sprouted barley (SB) assert that up to 25% less feed is required to maintain animal productivity, anecdotally claiming much greater nutrient digestibility of the SB. However, this was not substantiated in the current study where OM, NDF, ADF, and CP digestibilities were similar between SB and BG diets, and DM digestibility only showed a tendency to be slightly greater for SB diets (3 percentage units), which would dispute those claims. However, further in vivo animal studies with SB are required to substantiate the results of this continuous-culture fermentation study.

Proponents of SB suggest that feeding sprouts results in a less acidic ruminal environment compared with grains, which would reduce the occurrence of ruminal acidosis. It is important to note, however, that the increased fermentor pH with SB observed was marginal in the present study.

Conclusions: Supplementation of herbage-based and haylage based diets with 7-d SB increased true and apparent DM digestibility marginally (3 percentage units); however, it had no effect on fiber or CP digestibility, CH4 output, and bacterial efficiency. The small increase in digestibility coupled with the DM yield loss associated with sprouting barley could result in less digestible energy available to the animal and negative effects on animal performance when supplementing with high quality herbage diets, such as herbage or haylage. In this study, haylage-based diets produced 27% more CH4 per day compared with herbage-based diets, indicating the possibility of feeding high-quality herbage to mitigate CH4, compared with conserved forages. Further in vivo studies are required to evaluate the effects of SB supplementation of herbage-based diets on animal performance and to evaluate the economic and environmental sustainably of implementing sprouting technology on farms.


Abstract: The objective of the study was to evaluate 5 grains for use in sprouted fodder productions systems at the University of Minnesota’s West Central Research and Outreach Center, Morris, MN. Forage mass, mold score, dry matter, and forage quality were evaluated for varieties of sprouted organic barley, oats, wheat, rye, and triticale harvested at 7 d after the start of sprouting. During September 2014, on every Monday for 6 weeks, 28 fodder trays (0.6 m x 1.8 m) from a FarmTek Fodder Pro system were filled with 4.1 kg of pre-soaked grain, which was soaked for 24 h. Each tray was automatically watered 3 times a day for 4 min each time. On the seventh day, each tray was harvested, weighed, and visually scored on a 1 to 5 scale for mold by one observer. Ten random samples from each sprouted grain each week were saved for dry matter and forage quality analysis. Sprouted forage samples were sent to Rock River Laboratory, Inc., Watertown, Wisconsin, and were analyzed by wet
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chemistry for DM, CP, NDF, and TDN. Data were analyzed using the MIXED procedure of SAS. Independent variables for analyses were the fixed effects sprouted grain, and date of harvest and replicate were random effects. Sprouted barley (9.3 kg), oats (9.0 kg), and wheat (8.8 kg) had greater (P < 0.05) forage mass per tray than sprouted rye (7.8 kg) and triticale (6.3 kg). Mold scores were lower (P < 0.05) for sprouted barley (0.04) and oats (0.03) compared with sprouted rye (2.8) and triticale (4.8). Sprouted barley DM (15.4%) was lower (P < 0.05) than sprouted oat (19.1%), rye (19.8%), triticale (24.2%), and wheat (18.9%) DM. Concentrations of CP averaged 15.6%, 13.1%, 12.8%, 17.0%, and 17.9% for sprouted barley, oats, rye, triticale, and wheat, respectively, and they were different (P < 0.05) from each other. The NDF was greater (P < 0.05) for sprouted barley and oats (34.4% and 44.8%, respectively) compared with sprouted rye, triticale, and wheat (23.6%, 20.4%, and 26.7%, respectively). Sprouted triticale (79.7%) had higher TDN than sprouted oats (71.8%), which was the lowest for TDN. In summary, the results show that sprouted barley has the highest forage quality for fodder production systems.


Abstract: Leafy green vegetation is a source of apparently still unidentified nutritional factors. The grass factor for poultry usually gives a growth response on practical type rations (Scott, Gilsta and Goffi, 1951; Scott, 1951; Scott and Jensen, 1952; Slinger, Pepper and Hill, 1952). Patterson (1937) and McCandlish (1939) increased gains in steers when sprouted corn was added to the ration with the latter researchers showing 15 to 20% increase in gain. However, McCandlish and Struthers (1938) and Thomas and Reddy (1962) showed that the addition of sprouted corn had no significant effect upon ration digestibility. It was the objective of this research to investigate further the effects of adding various levels of “oat grass” to low and high concentrate rations for beef steers using a natural source of protein.

Old study but saw similar results in DM loss (18%). Study looked at rumen fluid and manure samples. Like other studies fodder had higher levels of crude protein and fiber, higher ash.


Overview of fodder and profiles a farm family using fodder for 9 months. Discussion of the benefits are given but warning that fodder fails, no feed!) $184/ton as fed.


Abstract: Brief and dairy cattle from four different herds in southern and central Queensland fed hydroponically-produced sprouted barley or wheat grain heavily infested with Aspergillus clavatus developed posterior ataxia with knuckling of fetlocks, muscular tremors and recumbency, but maintained appetite. A few animals variously had reduced milk production, hyperaesthesia, drooling of saliva, hypermetria of hind limbs or muscle spasms. Degeneration of large neurones was seen in the brain stem and spinal cord grey matter. The syndrome was consistent with A clavatus tremorgenic mycotoxicosis of ruminants. The cases are the earliest known to be associated with this fungus in Australia. They highlight a potential hazard of hydroponic fodder production systems, which appear to favour A clavatus growth on sprouted grain, etc.

They conclude, “Feeding sprouted grains to ruminants has recently become more common in Australia. Contributing reasons included widespread drought conditions during 2002-3 causing feed shortages, and a belief that nutritional advantages may accrue from feeding grain as sprouts. Studies of the nutritional value of hydroponically sprouted grains for ruminants do not support the latter view. The cost of barley sprouts has been calculated as about $1/kg dry matter, which compares poorly with grain at $0.3/kg dry matter. A clavatus neurotoxicity has occurred sporadically in many places in the world where sprouted grains have been fed to cattle. Our cases confirm that Australia is not exempt from this pattern and that any advantage gained from this practice can be heavily outweighed by the largely unpredictable risks of poisoning in ruminants and of extrinsic allergic alveolitis in humans exposed to A clavatus spores.

Abstract: In order to analyze the productive and reproductive behavior of lactating Salers cows with calf there was used hydroponics green fodder (HGF) as supplement from May 1st to July 2 of 2002. There were 35 cows used with 42±4.55 open days. They were paired according to the calving date and randomly assigned to one of two treatments: rangeland forage plus HGF as supplement plus green fodder (GF) and rangeland forage plus irrigated prairie forage (PF). The consumption of forage was 1.07 and 1.32 kg/DM/d of GF and 2.66 and 0.88 kg/DM/d of PF in May and June, respectively. Both groups were bred with fertility tested registered Salers bulls. The cows on PF lost weight (P<0.05) from day 28 (496.88±13.34 kg) to day 56 (459.99±13.34 kg) of the experiment, the GF cows maintained the live weight on the same period (506.13±13.73 kg and 497.60±13.73 kg, respectively). The cows showed daily live weight lost (P<0.05) on PF and daily weight gain on GF (-0.684±0.09 vs. 0.196±0.09 kg/d respectively). The calves showed differences (P<0.05) between treatments in live weight at day 56 (106.8±2.97 kg vs. 118.51±3.07 kg on PF and GF respectively). The daily average weight gain of calves from day 0 to 56 was 0.535±0.04 vs. 0.759±0.05 kg/d on PF and GF, respectively. There was an effect of treatment on cow body condition BC (P<0.4). The treatment means were 4.63±0.07 vs. 4.81±0.07 units of BC for PF and GF, respectively. The cycling cows were 17.65, 23.53 and 76.47% for GF and 11.11, 22.22 and 38.89% for PF on the first, second and third samplings, respectively. The estrous cycle was determined on the animal by the presence of more than 1 ng/ml of progesterone on blood serum. The treatments show difference (P<0.05) on the last sampling period being higher for GF. There were no differences (P>0.05) for pregnancy rates on November 2 of 2002 (88.24 vs. 70.59% for PF and GF, respectively). The HGF show being a viable supplement for the lactating cows to sustain weight on rangelands with an acceptable weight gain of calves.

While this research focused on beef production, it seemed to be one of the few that compared pasture with fodder treatments: control was grassland (no mention of species) plus 1 h of “meadow” (mix of oats, ryegrass, cereal rye, and triticale; sown with sorghum sudan). They determined that fodder can be a good supplement to pasture/meadow, especially during “summer slump.”


Similar to other Naik et al. works, the article reviews the benefits of fodder production in climates where forage availability is scarce, due to lack of adequate water resources, available land, and labor. They describe hydroponics as “hydro” = water and “ponic” = working. “During sprouting of cereal grains, the vitamins content, particularly B-group vitamins are increased...sprouting provides a good supply of vitamin A, E, C and B-complex.” Benefits they cite include: viable alternative technology for areas with no grazing facility or water scarcity; no need for soil prep, weed removal, and fencing; and high yield in small area within limited time period; less labor time; no post-harvest loss; year round supply of high quality fodder; can be organic; increase in digestibility of nutrients; improves general fertility, conception rates, appearance of coats; rich source of anti-oxidants in the form of beta carotene, vit A and E; rich in enzymes generally alkaline and perhaps eliminating anti-nutritional factors like phytic acid. Major challenges include: high initial investment in infrastructure; cost of system highly dependent on cost of seed (90-98%); should be considered as an alternative to conventional forages and where forages cannot be cultivated by any reasons; high moisture content.


Abstract: Hydroponics maize fodder of 7 days growth was fed to 6 dairy cows divided into two equal groups (BW 442 kg; avg. milk yield 6.0 kg). Animals were offered 5 kg concentrate mixture and ad lib. jowar straw along with either 15 kg fresh hydroponics maize fodder (T-HF) or conventional napier bajra hybrid (NBH) green fodder (T-CF) for 68 days. The hydroponics maize fodder (HMF) had higher CP (13.30 vs 11.14, %), EE (3.27 vs 2.20, %), NFE (75.32 vs 53.54, %) and lower CF (6.37 vs 22.25, %), TA (1.75 vs 9.84, %) and AIA (0.57 vs 1.03, %) than NBH. HMF intake was low (0.59 kg DM/d) than NBH (1.19 kg DM/ d) by the cows. However, the DM (2.05 and 2.17 %) was similar in both the groups. Digestibility of CP (72.46 vs 68.86, %) and CF (59.21 vs 53.25, %) was higher (P<0.05) for cows fed HMF. The DCP content (9.65 vs 8.61, %) of the ration increased significantly (P<0.05) due to feeding of HMF; however, the increase (P>0.05) in the CP (13.29 vs 12.48, %) and TDN (68.52 vs 64, %) content was nonsignificant. There was 13.7% increase in the milk yield of T-HF (4.64, kg/d) than the T-CF group (4.08 kg/d). The feed conversion ratio of DM (2.12 vs 2.37), CP (0.29 vs 0.30) and TDN (1.45 vs 1.52) to produce a kg milk was better in the T-HF than the T-CF group. There was higher net profit of Rs. 12.67/-/ per cow/d on feeding HMF. It can be concluded that feeding of HMF to lactating cows increased the digestibility of nutrients and milk production leading to increase in net profit. They cite Pandey and Pathak (1991) who reported that the digestibilities of the nutrients of the hydroponics green fodder are comparable to the highly digestible legumes like berseem and other clovers.

They found higher milk production in fodder fed cows; said fodder had better feed conversion ratio.

Abstract: Production of hydroponics fodder involves growing of plants without soil but in water or nutrient rich solution in a greenhouse (hi-tech or low cost devices) for a short duration (approx. 7 days). The use of nutrient solution for the growth of the hydroponics fodder is not essential and only the tap water can be used. In India, maize grain should be the choice for production of hydroponics fodder. The hydroponics green fodder looks like a mat of 20-30 cm height consisting of roots, seeds and plants. To produce one kg of fresh hydroponics maize fodder (7-d), about 1.50-3.0 litres of water is required. Yields of 5-6 folds on fresh basis and DM content of 11-14% are common for hydroponics maize fodder, however, DM content up to 18% has also been observed. The hydroponics fodder is more palatable, digestible and nutritious while imparting other health benefits to the animals. The cost of seed contributes about 90% of the total cost of production of hydroponics maize fodder. It is recommended to supplement about 5-10 kg fresh hydroponics maize fodder per cow per day. However, sprouting a part of the maize of the concentrate mixture for hydroponics fodder production does not require extra maize. Feeding of hydroponics fodder increases the digestibility of the nutrients of the ration which could contribute towards increase in milk production (8-13%). In situations, where conventional green fodder cannot be grown successfully, hydroponics fodder can be produced by the farmers for feeding their dairy animals using low cost devices.

This article describes why there may be health benefits from fodder and also reviews history of fodder production which seemed to begin in mid-1800s in France. “The nutrient contents of hydroponics fodder are superior to certain common non-leguminous fodders but comparable to leguminous fodders.”

“During sprouting, the activities of the inactive enzymes of the grains are increased due to the neutralization of the enzyme inhibitors and these enzymes ultimately break down the reserve chemical constituents such as starch, protein and lipids into various metabolites viz. sugars, amino acids and free fatty acids. Furthermore, these are used to synthesise new compounds or transported to the other parts of the growing seedling including the breakdown of nutritionally undesirable constituents. The enzymes cause the inter-conversion of these simpler components leading to increase in the quality of the amino acids and concentration of the vitamins. Sprouts are rich source of anti-oxidants in the form of β-carotene, vitamin-C, E and related trace minerals such as Se and Zn. As sprouted grains (hydroponics fodder) are rich in enzymes and enzyme-rich feeds are generally alkaline in nature, therefore, feeding of the hydroponics fodder improves the animals’ productivity by developing a stronger immune system due to neutralization of the acidic conditions. Besides, helping in the elimination of the anti-nutritional factors such as phytic acid of the grains, hydroponics fodders are good source of chlorophyll and contain a grass juice factor that improves the performance of the livestock.”


Abstract: Barley grain was sprouted hydroponically in the light at 21°C for 1-7 days. Samples were freeze-dried, ground through a 1-mm screen and analyzed for proximate nutrients, amino acids, minerals and fatty acids. During sprouting, weights of dry matter (DM), starch (NFE) and gross energy decreased markedly (P < 0.05). A smaller reduction in protein weight also occurred. Weights of ash and fat increased slightly and fibre increased markedly with increased sprouting time. Among the amino acids, weights of cystine, glutamic acid and proline decreased, whilst aspartic acid and alanine increased. There was a slight gain in Cu, Na and Zn due to the mineral content of the water source. The fatty acid concentration showed a significant (P < 0.05) positive relationship with growth period. These results indicate that the younger the sprout, the greater its nutrient weight. Thus, it would appear that Day 1 sprouts are nutritionally superior to Day 4 sprouts which are currently being fed to livestock. It would also appear that field-sprouted grain, which is analogous to Day 1 sprouts in terms of gross physical appearance, would have a minimal loss of nutrients.

An old article, yet it supports findings in other, more recent work, i.e. fresh weight gain due to water uptake, decreases in DM weights, gross energy (GE), and NFE. They saw a germination rate of 60 to 65%, citing that seed-grade grain has better germination rates but is prohibitively expensive. They saw in increase in fiber due to the number and size of cell walls. Also saw an increase in ash and total lipids. Interestingly, they did measure fatty acids—they said, “changes in concentrations of linoleic, linolenic and stearic acids showed a significant (P < 0.05) linear relationship with sprouting time.” The concluded, “Because these changes in nutrients are related to time, the younger the sprout, the greater its nutrient weight. Thus, it would appear that Day 1 sprouts are nutritionally superior to Day 4 sprouts, which are currently being given to livestock by producers using such hydroponic sprouting systems. It would also appear that field-sprouted grain, which is analogous to Day 1 sprouts in terms of gross physical appearance, would have a minimal loss of nutrients.”


This poster published as part of Chico State’s Organic Dairy projects included the following introduction: California’s drought has severely impacted the state’s $8 billion dairy industry. Over 200 dairies went out of business in the last 2 years alone because of the disparity between cost of production and milk prices. Producers are interested in sprouted barley or triticale, as
an alternative energy source that can be grown on-farm and used as a replacement for the concentrate component of the ration, which tends to be the most expensive. Producers using sprouts have reported significant cost savings without loss in milk production suggesting fodder can be used as a replacement for grain in the dairy cow ration. Due to the unknown effects of sprouted grains on a dairy cow ration, we hypothesize because sprouted grains are able to break down so quickly in the rumen, it will provide available energy for rumen microbial replication and digestion; thus improving the rate of degradation of all feeds.

Conclusions were as follows. Feed degradation analysis showed an advantage to fodder-fed heifers between 12 and 36 hours of feed deposition, suggesting that a fodder-based TMR provides a more favorable rumen micro-climate for a more rapid break-down of feeds. All feeds tested (sprouted grains, corn and alfalfa) showed a more rapid dry matter degradation rate under a fodder-fed rumen environment. Fiber residual analyses suggest higher fiber breakdown in sprouted grain samples while exhibiting more comparable results in the alfalfa samples. Determining fiber breakdown within the corn sample was too variable to analyze. Additional data analysis is currently underway to assess percentage of protein breakdown within each sample as well as VFA concentration in rumen fluid. Collectively, results from these experiments should provide some indication for the mechanism of action and the overall utility of fodder as a replacement for grain in the dairy cow ration.


This article profiles Be A Blessing Organic Dairy Farm owned by John Stoltzfus and family in New York. They invested $5000 in their system and say a 10 pound ration costs $0.30/pound versus $4 per pound of cornmeal and soymeal mix. John says 95% of nutrients available to the cow.


Article suggests that gain in weight from fodder—1 kilogram of seed produces 6 to 10 kilograms of fodder—most of the gain comes from water; they saw a reduction in dry matter weight of fodder when compared to grain seed. During soaking and germination, seeds lose dry matter (DM) as they use their own energy reserves for growth. Sprouts can regain some DM weight with the uptake of minerals and effective photosynthesis however in the short growing cycle there is most commonly a DM loss ranging from 7% to 47%.

Many factors affect the yield of sprouts in particular irrigation, water quality and pH, grain preparation, grain quality and variety, seedling density, temperature and growing duration. Hygiene is important to reduce the risk of mould. Soaking period, nutrients and light have some influence.

DM decreases but ash content and protein levels increase. Processed grain and grain sprouts are both highly digestible, nutritious foods. The energy in grain is largely starch and sprouting converts much of the starch to sugars. Sprouting also increases fibre levels.

Since sprouts are much wetter than the other feeds listed. The metabolisable energy (ME) levels of sprouts on a DM basis are similar to grain and cottonseed meal, for example around 10 to 13 megajoules (MJ).

Profitable use of sprouting grain as a feed source for commercial cattle production appears unlikely. Although hydroponically sprouted grain is a highly nutritious feed, it has major limitations for profitable use in commercial cattle operations, including its high cost of production (cost of capital, depreciation, labour, running costs), scale of operation, handling of very high moisture feed and risk of mould. Mould is a common problem that increases labour and costs, reduces animal performance and sometimes results in stock deaths. A problem that people may have in evaluating the cost of sprouts is failing to account for its high moisture content, labour input and capital costs. Therefore, many people think it is much cheaper than it really is. It is best to evaluate supplements on a dry matter basis and examples are given in this report. Sprouts have been found to cost from two to five times the cost of dry matter compared with the original grain. Ultimately, it is the performance relative to the cost that determines profitability. There are many unsubstantiated claims of exceptional live weight performance due to hydroponic sprouts. Tudor et al. (2003) recorded higher than expected performance over 48 days and concluded that further rigorous research was required. The performance potential of sprouts as a supplement to dry pasture remains largely unknown.

Hydroponic sprouts may have profitable application in intensive, small-scale livestock situations with high value outputs, where land and alternative feed costs are high, and where the quality changes (eg less starch, more lysine, vitamins, etc) due to spraying are advantageous to the particular livestock. Such quality improvements may be more applicable to horses and humans than to commercial cattle. Sprouted legumes have been used to prevent scurvy in humans (Leitch 1939). For horses, sprouts provide high energy and protein, low starch, no dust and a useful supplement of vitamin E and biotin (Cuddeford 1989). Ruminants synthesize many of their own vitamins in the rumen. Cattle are also less efficient at using high quality feeds than horses or monogastrics such as pigs and people. Full feeding for commercial cattle production with sprouts is inappropriate due to its high moisture content, high cost and scale of operation. As with any supplementary feeding, the cost and performance of sprouts should be compared with other feeds. The future of hydroponic sprouts in commercial cattle production depends on: 1.
The cost of nutrients and performance supplied by sprouts relative to other feed supplements; and 2. Understanding the real cost and value of sprouts in animal production.


Summary: Two dairy farms in Pennsylvania are participating in this study designed to evaluate the feasibility, effectiveness and challenges of using a sprouted grain system with a third providing technical input and data as someone who used but has discontinued use of fodder. Data collection has begun on both farms actively using fodder. One farm has a homemade system, the other has a purchased sprouting system. We have learned that increased milk production is not the only reason to implement a sprouted grain system. There are other perceived animal health benefits (such as reduced somatic cell counts) that may make sprouted grains more attractive to farmers to improve milk pay price. However, we are trying to determine whether the increased cost of sprout production, especially labor, makes these systems feasible. Each farm has resource challenges and opportunities that impact their ability to utilize sprouts in their rations. Our goal is to collect data and later interview the farmers to understand their reasoning for utilizing sprouted grains as well as to analyze feed and milk production/composition as well as evaluate the economic feasibility of these systems. Data collection will continue into 2015.


Summary: In sum, per lb. of dry matter produced, the fodder system had a $0.045 cost for investment; $0.23 cost for labor; $0.12 cost for seed; and $0.01 cost for water, electrical and other for a total cost of $0.40 per lb. of dry matter produced. This fodder cost can be compared to feeding good quality hay for $0.107 per lb. of dry matter for good quality hay that has 13% less TDN. So, unless significant benefits can be gained due to the increased digestibility of the fodder, this is a costly method of producing feed for dairy producers. However, hydroponic sprouts may still have good application in organic, intensive, small-scale livestock with high value outputs or in areas with extremely high land or alternative feed prices. Organic dairies needing to feed very high forage levels year round that can produce their own seed for reasonable costs and have excess labor available, may have reason to experiment further with the hydroponic fodder system. Research data on dairy cows is limited to determine definitively whether or not the feeding characteristics of the fodder changes production or body condition enough to warrant the additional cost. Due to changes in the nutritive characteristics of the fodder (less starch, more sugars, vitamins and lysine) monogastrics such as people, horses, swine and poultry may have more benefit. In the end analysis, it us ultimately animal performance relative to the alternative costs that determines profitability and usefulness. With a cost 3 to 5 times that of the original barley grain or other readily available feed sources, increased animal performance of that magnitude is highly unlikely, but more research seems necessary.

Tranel conducts an economic estimate of fodder systems – he calculates a cost of $0.40 per pound of DM. His study showed an increase, not decrease of DM of fodder to grain, unlike many other studies in the literature review.

**Trickett, S. 2010. How your grass can be greener. Farmers Weekly. 30 July 2010.**

Interview with director of H2O Farm, commercial hydroponic fodder system manufacture in the UK. Mostly a sales-oriented type of article.


Introductory paragraph: The concept of using hydroponically sprouted cereal grain as nutritious fodder is not new (Leitch 1939, cited by Peer and Leeson 1985). Sprouting in grain is associated with losses in dry matter (DM) and increases in crude protein concentration. Hydroponic fodder is nutritious, but the high moisture content, 84-91%, significantly reduces the concentrations of energy or protein in the feed. When ‘converts’ talk about the benefits, they do not consider DM content.

The researchers conclude, “These nutrients could result in enhanced microbial activity and growth in the rumen, and consequently, better than expected utilisation of the poor quality hay that was also fed. Therefore, the fermentation of the young hydroponically sprouted barley may have provided far greater energy than was estimated by the in vitro DM digestibility assay.”


Brian Willsley received a SARE farmer grant in 2014: http://mysare.sare.org/mySARE/ProjectReport.aspx?do=viewRept&pn=FNC14-981&v=2014&t=2. His blog concludes, “Our decision to shut the fodder system down between June and September was two-fold. Barley hates warm weather, which makes it difficult to grow hydroponically. Pastures usually are at peak by June, then slow down as the ground temperature increases. We found that by June, the barley in the system has a germination rate of about 20-30 percent. Not only does it make growing
fodder more expensive, but it also increases the mold and insects. As we may have a need in the future to have dependable forage we can produce, we decided to run trials of warm season plants while the system was shut down. We selected Sorgum-Sudan, Haybeans, and Pearl Millet. After discussions with agronomists at Mo Extension, we tabled the Sorgum-Sudan until we can test for prussic acid levels at various growth rates. Pearl Millet, while it likes the heat, does not seem to produce vegetation quickly enough to be a good option. Haybeans however, love heat, grow quickly and are readily consumed as forage by our livestock – both alpacas and sheep (the cows were left out on purpose). Our 1 month trial for haybeans consistently produced a 600% return – 6 lbs of soaked seed produced 36 lbs of forage in 8 days.”