Does Hydroponic Forage Production Make Sense?

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There are some things that are attractive at first look, but fall apart upon analysis. Maybe like that fancy car you bought which needed major work 3 weeks after you drove it off the lot. Hydroponic fodder systems may fall into that category.

There are a number of systems available on the web promoting this concept (try Googling ‘hydroponic fodder’ or ‘hydroponic grass’ on the web – there are plenty of sites).

**Looks good?** Who could think of a better forage for your animal than luscious sprouted leafy grain—just like the alfalfa sprouts on your sandwich! You can see videos on the web which show cattle and horses gobbling up sprouted grain like a vegetarian at a salad bar.

![Figure 1. Hydroponically-grown barley sprouts after 6 days of growth.](image)

**But things are not always as they seem!** Let’s see if this concept makes sense.

**What are Hydroponic Forages?** Typical hydroponic systems are produced under artificial conditions (i.e., greenhouse or lighted systems in a closed box), with regular watering, producing a ‘crop’ within 6 - 7 days. This amount of time is sufficient to sprout seeds such as barley, wheat, and sunflower, or legumes like peas, to produce a 4 to 8 inch growth of green shoots.
One website indicated that 2 lbs of seed will make 9 - 12 lbs of fodder, and they paid $14.50 for a 48 lb bag of barley (30 cents/lb), or $10 for 50 lbs of wheat (20 cents/lb). Similarly, another web source indicated that 10 lbs of seed produced 50-60 lbs of ‘forage’.

This sounds quite amazing (2 lbs. makes 12 lbs. in a week!), that is until you start thinking about it more carefully.

**Be sure to correct for dry matter.** All animal rations consider feeds primarily as dry matter (DM) equivalents, since water is provided separately and all of the other nutrients required by the animals to live, grow, and lactate are in the dry matter (DM) portion. Thus, a feed with 90% water (such as sprouted grain) has considerably less ‘feed value’ than something with only 5% water (such as the grain itself), on a pound for pound basis.

So, in the example above, if 2 lbs of seed is 95% DM (a likely scenario), and the resulting fodder is 10% DM (also a likely scenario), then 1.90 lbs of DM of seed (2 lbs at 95% DM) produces about 0.9 to 1.2 lbs of dry weight fodder (9 - 12 lbs of total fodder at 10% DM) which is no net DM gain at all; in fact, it is a loss of DM!

However, this is just a back-of-the-envelope calculation. Let’s try testing the concept using real data from real sprouted fodder.

**Dry Matter and Quality Analysis of Samples.** A local friend who is working with hydroponic forages brought us some sprouted hydroponic barley he grew in one of these sprouting systems, which we analyzed. We analyzed two batches. Here are the results:

**Analysis 1.** In the first analysis, we had barley sprouts at either 6 or 7 days of growth. In the 6 day batch, we measured an output of 14.8 lbs of sprouts, roots and spent barley seeds, starting with 2 lbs of raw barley seed. We then determined the dry matter (DM) content of the whole plants to be 9.7% (90.3% water), meaning that there was 1.44 lbs. of DM in the sprouts. Since the 2 lbs. of seed was 95% DM, there was a loss of 0.46 lbs DM during sprouting (1.9 lbs. DM – 1.44 lbs. DM). Thus sprouting resulted in a loss of 24.2% of the DM that was in the seeds after 6 days of growth. The net loss of DM after 7 days of growth was even higher at over 30%! In fact, on a dry weight basis, little of the shoot, root and spent seed mixture produced was green shoots (13% after 6 days and 17% after 7 days of growth). Most of the weight was in the root/seed mass (the whole mass is generally fed in hydroponic forage systems).

**Analysis 2.** We analyzed a second batch of sprouted barley from a different 6 days of growth. Similar to Analysis #1, this resulted in a 25% loss in DM over 6 days, but with considerable variation between pods (Table 1). Similar to the first Analysis, shoots were about 15.5% of the sprout DM. Quality of the sprouts appeared to be good, using a standard NIRS equation, at about 15% CP, with low ADF% and NDF%.
Why do seedlings lose dry matter in 6 or 7 days of growth? Plant physiologists tell us that seeds utilize the starch stored in the seed during the first week or so of growth before photosynthesis and root uptake of minerals kick in to cause dramatic increases in growth. So it’s not surprising that the total dry weight of the plant (i.e., seed, root, shoot) decreases during that time, rather than increasing, because the plant is using up stored carbohydrates from the seed. Later, a plant is quite capable of producing its own food from sunlight and CO₂, and begins to gain weight rapidly. So such hydroponic systems are likely to lead to a net loss in dry matter and carbon up to about 10-14 days of growth.

Sustainability? Is this system easier on our natural resources? It would be hard to argue that a completely artificial system with a requirement for electrical energy (lights or fans) and a structure such as a box or greenhouse is superior to field grown forages with regards to sustainability. However if the yield levels were high (i.e., high DM produced per unit water or unit energy), it is possible that it could be justified but, as we’ve seen above, that is not the case. However in fact, the system leads to a net loss in dry weight recovery, albeit with a shift from starch (in the seed) to fiber and pectin (in the roots and sprouts). We haven’t calculated Water-Use Efficiency for a hydroponic system, but with the yield levels given, it is unlikely to be superior to field-grown forages, especially if the water used to grow the grain is considered. Additionally, pastures, alfalfa and field-grown grains create wildlife habitat, N₂ fixation (for legumes such as alfalfa), and have other environmental benefits.

Can hydroponic fodder production be profitable? If you have animals, you have a choice whether to 1) graze, pasture, or grow your own hay or silage, 2) purchase hay or other forages, or 3) grow the feed hydroponically. Alternatively, feed grains like barley can be fed directly to livestock. So which makes most sense? We calculate that one ‘pod’ starting with 104 lbs. seed (52 weeks x 2 lbs./week) would produce about 60-80 lbs. DM per year. This is approximately 2/3 of a 125 lb. bale of hay (alfalfa, grain, or grass) per pod, which (these days) goes for between $12 and $18/bale. So a hydroponic system at a minimum must beat that cost (e.g. be cheaper than about $8-$12/pod/year), including infrastructure, seed, and labor. Another way to look at it, consideringonly the cost of seed at 18 cents/pound (not the infrastructure of lights, box, trays, greenhouse, etc. or labor), the hydroponic cost of...
production would equal about $461/ton hay (90%DM). If one includes the cost of the infrastructure, energy inputs and labor, the real cost might be double that. During the past 10 years, California top-quality alfalfa hay has only occasionally been over $300/ton of DM delivered, and in 2013 generally ranged between $220 and $260/ton (90%DM hay). So the economics of production appear to be quite questionable. Additionally, one should consider that one is losing DM each week in a hydroponic system compared with feeding barley grain directly.

**But isn’t the nutritional quality better?** There is little doubt that sprouts are highly palatable to livestock—witness the relish with which animals consume it in web photos and videos. High moisture feeds are frequently quite palatable. However, we do not have data to suggest that barley ‘forage’ is superior to feeding other forages with similar analyses, or even better than feeding barley directly. The feeding value of the shoot/seed/root mixture may not be better than the initial barley seeds themselves. Fazaeli et al. (2012) found that true protein decreased, and the non-fiber carbohydrate, Metabolic Energy, and in-vitro gas production decreased in sprouted barley compared with the raw seed, and there were losses in DM yield. The lack of improvement in either quantity or quality let them to recommend against feeding sprouted seed vs. raw seed. Since stored starches have been used to grow the seedlings (loss of DM), the crop is likely to lose energy (also known as TDN or NEL), and may have actually lowered its feeding value compared with the seeds themselves. Barley sprouts should probably still be classified as a ‘seed-type-feed’ rather than a true forage, since the NDF and ADF (fiber) levels are relatively low.

**Where Hydroponic Forage May Fit.** Although the economics, the yield, and the quality of hydroponic sprouted grain forage are not highly favorable, the concept has a great appeal to those who wish to be more self-sufficient in feed. It may fit for those producers who do not have local sources for hay or forage, or simply want to be more self-sufficient. For small animal producers (rabbits, etc.), this may offer a ready source of palatable feed. Hydroponic sprouted grain may also be an appealing feed which varies the diet for animals fed only hay and grains, although we should caution that the costs must be considered.

**Summary.** The hydroponic concept may be appealing at first look, but it generally doesn’t hold up to scrutiny after careful thought. Its main problem is that it exhibits a net loss in terms of DM yield of 24 to 30% after 6 to 7 days of growth. The DM yields of hydroponic systems are actually negative, compared with the initial seed input. Additionally, there is likely to be a loss in feeding value of sprouted grain compared with raw grain, on a dry weight basis. This result makes sense when considering that the seed must utilize stored carbohydrates in order to drive growth of the seedling. The costs per pound or ton produced are likely to be significantly higher per unit hay equivalent (or feed grain equivalent). Although hydroponic forage has great appeal to those who wish to be more self-sufficient in feed supply, the yield, quality, and costs of this system appear not to be favorable.

**Reference:**
