Interview: Dr. Merle H. Jensen

If we use our technology, we can feed double the population

Dr. Jensen is Assistant Dean for Sponsored Research and professor of plant science at the College of Agriculture, University of Arizona. He has worked in the area of controlled environment agriculture for almost 30 years, with experience in over 60 countries. He serves as adviser, on either the government, university, or private level, on work in China, Malaysia, Japan, Egypt, Israel, and Mexico. He was interviewed by Marcia Merry on May 25.

EIR: What's generally called hydroponics or controlled environment agriculture (CEA) has very high-yield factors compared to conventional farming. What do you say to refute the doomsayers who today assert that we have reached the end of the line in terms of agriculture productivity gains, and that the world is overpopulated?

Jensen: I think that, first of all, we are probably only using one-fourth or one-third of the technology that has been developed through research in recent years. If we were just to use all that we had available in technology, we could probably feed double the world population. So it's a matter not so much of having enough information, but of using what we have. And one of those technologies, of course, is controlled environment agriculture. The whole issue of hydroponics comes to mind.

I want to discuss a definition of hydroponics, because I think that it's important that we start with a base that we fully understand. I'm going to read a definition that I've just put into a book for the World Bank: "Hydroponics is a technology for growing plants in a nutrient solution (water and fertilizers) with or without the use of an artificial medium (such as sand, gravel, vermiculite, rock wool, peat moss, sawdust, and so on) to provide mechanical support. Liquid hydroponics systems have no other supporting medium for the plant roots, while the aggregate systems have a solid medium of support."

So that is hydroponics, and that is what I'll be talking to.

Now the yields with hydroponics systems have far exceeded open field production. I have some comparative differences that we have measured in the deserts of Arizona and Arabia.

Hydroponic systems are almost always associated with greenhouses, where you have some control over the environment. Greenhouses are basically any means of extending the growing season, and that can extend the growing season into the winter months, when you would be heating, and into the summer months, when you would be cooling. Greenhouses basically are a framed or inflated structure covered by a transparent or translucent material that permits optimum light transmission for plant production and protects against adverse climate. Such a structure enables a person to walk inside, and may include mechanical equipment for heating and cooling.

Normally, hydroponics systems will be in a greenhouse structure. With greenhouse production, or controlled environment agriculture, or hydroponic CEA, you can have continuous cropping because of modification of the environment; whereas in open field agriculture, in most cases, you only have one crop per season.

I am going to talk in tons per hectare (see **Table 1**).

In the case of tomatoes, with the most recent technologies, we are getting 500 tons per hectare per year with one crop. We don't take one crop out and replant, and wait for that crop to come into production. We just keeping lowering that plant so it keeps producing. That plant gets like a Jack-in-the-Beanstalk kind of thing. It just keeps growing, and we keep pruning off the lower leaves, and dropping that plant in the row, and when we get to the end of the row, we just swing it around and bring it the other way. That plant will get to be 35-40 feet long. We just lay it right down in the row. You take all the leaves off the stems, so you have all these stems lying down in the row, and when we get to the end of the row, we just turn it around and bring it down. We have a double row per bed, and we just bring it down the other row. Quite incredible, actually.

You can imagine what we can do with greenhouses. And there are countries that are taking advantage of this.

EIR: What is going on in China now?

Jensen: When China decides to do something, whether it is the Red Guards and the Cultural Revolution, or whether it is agriculture, it completely sweeps the country. So once they find something, it is put into trial and they test it, and if it works, it goes. I'll give you a great example of that.

In the mid-1970s, they started doing work in just putting

TABLE 1

Yields of vegetable crops are higher under hydroponic cultivation than in open fields

	Hydroponic greenhouse			Open field
	Yield/crop (MT/ha)	No. crops/year	Total yield (MT/ha/year)	Total yield (MT/ha/year)
Crop				
Broccoli	32.5	3	97.5	10.5
Bushbeans	11.5	4	46.0	6.0
Cabbage	57.5	3	172.5	30.0
Chinese cabbage	50.0	4	200.0	—
Cucumber	250.0	3	750.0	30.0
Eggplant	28.0	2	56.0	20.0
Lettuce	31.3	10	313.0	52.0
Pepper	32.0	3	96.0	16.0
Tomato	187.5	2	375.0	100.0
New experiment tomato—1 continuous crop			500.0	100.0

Source: Dr. Merle Jensen; and J.E. Knott, *Handbook for Vegetable Growers* (New York: Wiley, 1966).

TABLE 2

Ratio of yield to water use is greater for drip than furrow irrigation

	Irrigation method	
	Furrow	Drip
Watermelon	20-25 tons per acre	25-35 tons per acre
Sorghum	4,600 pounds per acre	8,500 pounds per acre

Source: Dr. Merle Jensen

plastic on the ground. We in the United States were the early researchers on that; we found that putting plastic on the ground warms the soil, and many plants will respond to that. So China discovered that. And in 1979, they had 44 hectares. Ten years later, they had 2.867 million hectares, all over the country. In southern China, they extend the season in the winter, because in the Hong Kong area it gets quite cool for some crops like cucumbers, melons, and so forth; these crops really respond to soil warming. And it is used all the way up to Xinjiang province up by Mongolia. All the cotton up there is planted through plastic. You see plastic everywhere. In fact they grow peanuts on plastic mulch as far north as Beijing. That latitude is pretty close to New York [40°N].

That is quite remarkable. That is what China will do in regard to producing enough food to support its massive population.

EIR: What about water shortages in China?

Jensen: The water shortage is severe. What happens is that when you start covering surfaces with plastic, you prevent transpiration of water out of the ground. They are now starting to look at drip irrigation technologies.

What they do is quite clever with cotton. They will plant the bed, but on top of the bed, they will lay a plastic cover. It might be only 18 inches wide. In the middle of that bed, they will have a slight indentation, like a furrow. So that plastic is lying on the bed, over this furrow, and they will run water down this furrow, on top of the plastic. They poke holes in the plastic every 6 to 18 inches or so. The water seeps through the little hole, kind of like drip irrigation. Once it goes through the hole under the plastic, it doesn't evaporate out. So the only water used is that water which is used by the plant, and they are very careful to only put so much on, so that you wet the root zone, and not anything beyond that.

Those are the technologies that they are starting to use that will enable them to extend agriculture.

In using drip irrigation, you can irrigate *twice* the area than with conventional irrigation systems, because of the efficient use of water. By the time you have the efficient use of water—and you can put the fertilizer in the water, call it fertigation—you can do a number of things using water as the vehicle to get whatever chemical you might want on, by getting greater yields, and getting greater efficiency with the water, you probably would get [large factors of increased output.] The yields are quite outstanding.

We're getting three times the production from an inch of water than we would just with normal furrow irrigation. We are tripling production. For example, one acre-inch of water will produce 20 pounds of cotton with furrow irrigation, but it will produce 59 pounds of cotton with drip irrigation. The differences are dramatic with many other crops (**Table 2**).

That threefold increase is due to two things. One, you are using less water, and two, you are getting increased yield. You cut the water in half and that right away gives you double the amount of yield with the same amount of water. Then you get yield increases from factors including getting the fertilizer right to the root system, driving the salts away from the roots when you have drip irrigation, and so forth. Furrow irrigation drives the salts into the roots.

EIR: What is the method of using plastic film?

Jensen: They use a very thin, thin plastic, which is broken down by the light. It pretty much pulverizes and goes into the soil. But that doesn't say that that always works really well, because that plastic that's buried into the soil will not decompose, because it doesn't have the light. The plastic is photo-degradable. So what happens is that many times they will pull the plastic out of the field. And you can see literally mountains of plastic. That's a problem, to end up with all this waste plastic.

So they are taking that plastic and making it into furniture. They clean it, break it up, and put it back into usable plastic for other things like furniture, baseball bats for kids, toys, and things like that.

EIR: Plastic has been a mini-revolution?
Jensen: Plastics is a dirty word. I was going to term a book I have written *Plasticulture* [because of the importance of plastics in agriculture], but I didn't do that. I called it *Protected Agriculture*. But plastic has really revolutionized agriculture, because with plastic pipe, you don't have the corrosion problems. And you can go right to the field with some plastic pipe and some glue, and you're in business, warming the soils and protecting crops and so forth. In a lot of countries like India, for example, we had the Green Revolution, with the miracle wheat and rice developed by the Rockefeller Foundation. They say the next revolution will be plasticulture. It absolutely made a difference. And I am quite positive that China today is self-sufficient in food production by what it has been able to do with plasticulture.

EIR: What about gross amounts of land that could be added to cultivated area in China?
Jensen: [It can be done] if you use these water-conserving technologies. But at the same time, there are other technologies that we are using, such as water harvesting.

EIR: What about the other technologies, including the most energy-intense controlled environments near urban areas?
Jensen: In urban areas, it would be getting people more cognizant and aware of home gardening. At the same time, there is recycling of water. Black water is sewage and grey water is, for example, showers and washing. If we just started using that kind of water and recycling it, using it for growing crops, letting the crops filter the nutrient that is in the water—that's the kind of thing we need to be turning to.

Also, for water efficiency purposes, the yield of edible product per unit volume of water to produce that product is far greater with greenhouse/hydroponics than with open field irrigated cultivation. **Table 3** shows the comparisons for three crops.

There are other ways of extending scarce resources of water, such as water harvesting.

Water harvesting is where you might treat the land with salt, or you might grade it, so that when the water runs off, you collect it. They pitch the land. Sometimes if the land is not heavy with clay, or maybe the water will go down through it easily, they will give it a slight treatment of salt. Salt doesn't flocculate; it doesn't puff up the soil, and it becomes well aerated. Salt actually causes soil to pack. So when it rains, the water just runs off, and it doesn't go down into the soil. Say you have a slight V. In the bottom of the V, you might have a row of grapes. The water comes down the slopes on both sides, and it runs down the grape row, and excess goes into a pond. Then when you have a dry period, you just take the excess from the pond, and it goes through drip irrigation back to the plant row that is in the bottom of the V. It's pretty nifty.

These are ways of extending scarce resources of water.

TABLE 3
Less water is required under hydroponic cultivation than in open fields

Edible product (1 kilogram)	Hydroponic greenhouse (liters)	Open field (liters)
Cucumber	10	205
Lettuce	30	96
Tomato	13	123

Source: Dr. Merle Jensen

EIR: What about fish culture below, and plants growing in the space above?
Jensen: We have done tons of that kind of work. This is another way to extend food production. Let's say you've got all this water going out to the fields through canals. Let's grow some fish in the canals. So while you have expended the energy to pump that water, you use that, and grow something in that water while it is on its way to the field. And then the waste of the fish—this great nitrogen, you can't talk about better organic farming—you take the waste and put it onto the plant, and then the plant cleans that waste out of that water, so the plant becomes a living filter.

Look out environmentalist! We've got a system here that's really sound! I call it double harvest. We are doing two food crops with the same water and energy.

We're going with this "big time" now. We have remodeled our research programs to include this, and you're going to hear about it. We're doing tilapia and catfish. We're doing this in our canals, and it is really fantastic. We've got companies coming in and doing these kinds of systems now.

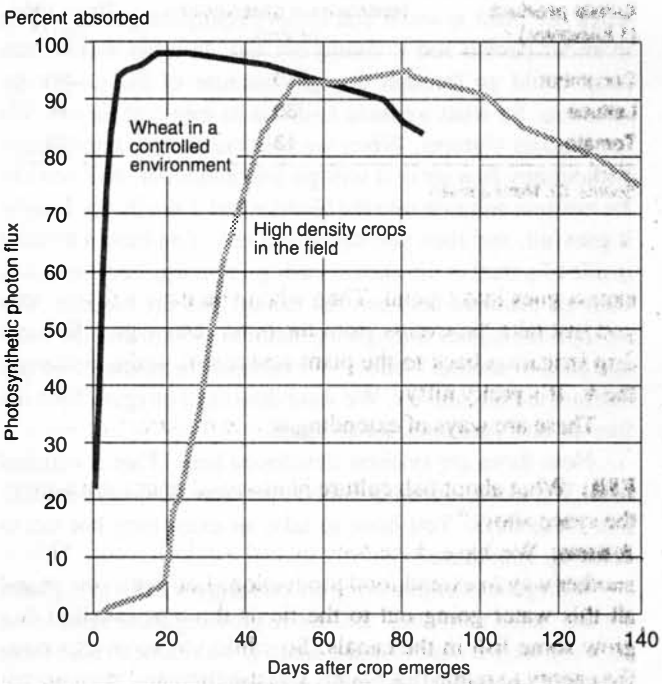
The farmer cannot afford the high cost of water today. But if he could share that cost with another kind of agriculture—with the fish farmer—now everyone wins. For the time being. Here we are going to grow all this protein, and really increase our food production, by coming in with an animal, like a fish, and then we go through drip irrigation.

EIR: Even hog farmers are using fish production to utilize wastes.
Jensen: You get the droppings and the waste and there is a lot of protein that has not been used in the waste of animals.

EIR: So if you project food output from a surface area, it is deceptive, because the surface can extend up or down.
Jensen: Down with fish. Up with growing crops in green-

FIGURE 1

Controlled environment crops can absorb more light



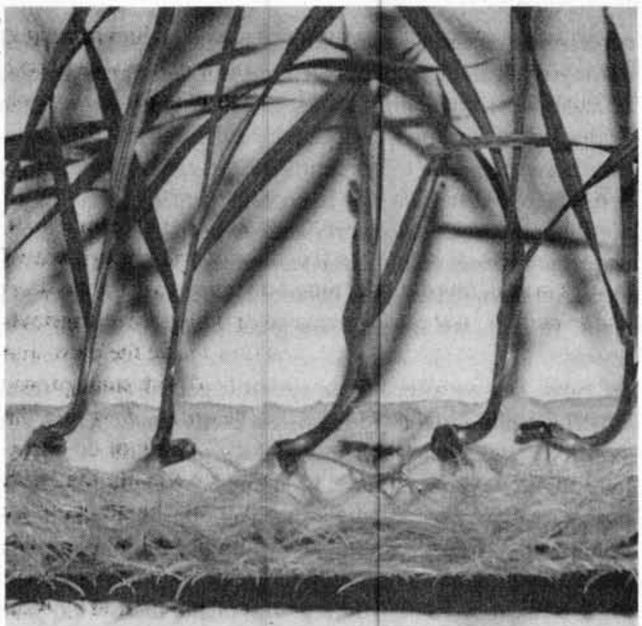
Source: B. Bugbee and O. Monje, "The Limits of Crop Productivity," *BioScience*, July-August, 1992.

Studies have shown that the average photosynthetic photon flux absorption over the life cycle of wheat, grown in a controlled environment, was 90%, in contrast to approximately 50% for a field crop of corn used for comparison. The crops compared were both high-density canopy crops (leafy cover).

houses. You get the crop in the air. So you produce on a cubic volume basis rather than on a square foot basis.

EIR: What are the frontiers of agriculture for completely controlled environments—space travel and going to the Moon?

Jensen: We definitely will go to and take food to the Moon. Even though we could take dehydrated food, and even though we may have a "salad machine" there, there is something more important. It's called mental health. We know without a doubt, that if you bring some kind of biology with you that grows and responds to human care, it has a tremendous impact on the mental health of people. We've seen that in retirement homes, in mental health clinics. Duke University has come out with studies. We know for sure that in barren environments, having plants growing does a lot for mental health. We can just talk about downtown in the city. We can talk about the Antarctic. A friend of mine is growing plants at the Pole right now, and they are finding a sort of hope, and a tranquility that comes over people. They are happier and more productive. And the same thing will be true on the Moon. I'm quite sure we'll see that.



Cut-away view of one row of wheat plants growing under special nutrient film conditions, in an experiment on controlled environment food crop production by NASA researchers. The healthy root mass, growing without soil, is shown along the bottom.

EIR: What are the technical outer limits of what you think you can get to grow in very adverse environments, such as Antarctica or on the Moon? What are the most problematical or interesting plant growth factors to investigate? Water, nutrients, kinds and quantities of light, gravity? What about the experiments on past Shuttle flights that found seedlings did not know which way was "down"? What are the interesting challenges in biochemistry?

Jensen: The interesting challenges include the fact that we are going to have to recycle or regenerate everything. So every bit of waste water or human waste, we are going to have to recycle. How can we pull that nutrient from the waste, so that we can put the nutrient back on to the plant in the right proportion? Especially the minor elements, like the boron, zinc, manganese, molybdenum? Those are used in very small amounts. We call them microelements. How can we pull those out and put them back in the ratio where the plants respond best? That's going to be probably one of the number one challenges.

At the same time, we have to pull out any virus particle that might be in that waste, that might cause danger to human health.

Then there is the question of what we are going to do with the refuse that we don't eat? The perfect plant would be the plant that we can totally consume. Then we don't have to worry about decomposing it.

EIR: Lettuce? But you can't live on lettuce.

Jensen: You can't live on lettuce. I've tried eating lettuce roots, because the wonderful thing is that hydroponics will allow you to get full recovery of the roots. But they are terrible, because there is a lot of salt in the roots. No matter how much Roquefort you put on it, it's not going to help. But we do know that those roots are 16% protein, and we can use that part as fish food. So that's the way to recycle there.

But then we have to worry about what's in the fish food, and what nutrient is left in the waste there. And we find that the waste from fish is quite balanced. It grows a pretty good plant. In fact, we have grown great plants totally on fish waste.

Now, can we afford those systems, getting protein from a fish? Getting protein from a fish is pretty efficient, but not as efficient as if you go directly to the grain itself.

I think sometimes that's probably why India has those kind of religious laws there—that you don't eat animals—because it is a very inefficient way to get protein. It's six times less efficient.

We're going to be working with plants that would give you the greatest "Harvest Index," meaning that most of it is edible. And what's left, you either compost it, or you ash it—with a muffle over, with high temperature. Then you pull apart the salts with maybe some electrofluoresis technology. You migrate the salts through a gel, then slice up the gel, and say, "That's potassium, that's boron."

I don't know if NASA is doing that, but it is what we call separation technology. It's going to be a very big challenge to do that. We want to get as much punch for the dollar as possible to produce as much biomass that has a great Harvest Index in a very, very small area. That's going to be very important. So we will breed plants that will do that. At the same time, we will breed plants that will have a leaf in such a position that it will be the best photoreceptor.

You know that leaves grow up and roots grow down because of what we call geotropism—by gravity. What's going to happen with no gravity, is that we won't have that. What do we do? One thing we will do is we will make the leaves come up with light—phototropism. We think that has possibilities. What about the solutions? We are going to put them in a container and they are not going to get away.

I'm growing plants in rubber balloons. I have this huge plant that is growing out of a rubber balloon, that is no bigger than a half pint. I have a six-foot tomato plant. It is 80% edible. Why? Because I've kept the root system so small, when normally the root system is as big [as the plant.] I have great photos of humongous root systems that equal the size of the top. In fact, I have to give the root system a haircut every week.

But what I've done is say, what happens if you take that root system and you put it into a small container? We'll let the roots stretch the container, which they can do in the rubber balloon. And I have these little hoses hooked up to that container, and we flush it rapidly. And I grow a six- to seven-foot tomato plant, with 15 pounds of fruit on it, and I'm growing it in less than a liter.

That's kind of like intravenous feeding. We've developed those systems.

What happens if you get air in that system? Your roots, when the plant is small and is developing, might be sitting in an air pocket and it would dry out. In other words, that plant could go through drought because of the no-gravity situation. So what we have to do, is to spin that air out. We use bladder systems. When we spin the air out, the solution without any free air in it will go into a bladder, and you run the nutrient solution into the bladder and it swells up. Finally it gets full, and then you squeeze it out. You have a bladder inside of a steel or aluminum casing. You squeeze it out now with air pressure between the casing and the bladder, like toothpaste. It goes through my balloon system and the roots and back to another bladder. We recheck the nutrient; we add nutrient to that, and air. We want dissolved oxygen. Spin the free air out. And back we go again.

Now those are systems developed here. That is original here. We're way ahead of our competition. It's very competitive these days. You have to take an extra long hot tub to come up with these.

With genetic engineering we could grow, let's say, plants for the "salad machine," and we're growing these salads, but let's say we we want to make soup. It's a shame to take these beautiful vegetables and make soup out of them. So what I'll do is grow callus through tissue culture. I take a plant cell, and I put it onto a nutrient medium we call agar, or some kind of nutrient medium, and I proliferate that cell to produce massive amounts of cells, and I just make it into soup. And I can eat that.

You have growth regulators, hormones, and so forth. These will cause these cells to proliferate and grow. They just multiply like crazy. Normally what is done is to grind those cells up, to separate them, and then put chemicals in. That causes them to make roots and shoots. But we wouldn't do that. We would grow this callus material. We would provide nutrients to these cells and we would have great proliferation of callus. It would take a few months to get soup, depending on the species. Some grow very rapidly. We could have these callus machines where we produce our own soup.

We tried this with carrots, but they don't taste like carrots. But celery does. So we have to find the taste test to go along with the proliferation of these cells. We just grow the cells. We separate the cells from the agar. We throw in some chunks of cabbage and whatever, and you have yourself a nice gruel.

EIR: It's a revolution in cuisine.

Jensen: Exactly. But you have to have bulk; you have to have roughage. And we have that with salads, and so forth.

EIR: Free trade advocates oppose nations' rights to national food production, utilizing their own resource base and technologies. The free traders rationalize that food should be produced where it is "competitive" and hauled long distances. What do you think about the question of the sovereignty, of the right to national food self-sufficiency?

Jensen: Food security is important. That's why the Norwegians subsidize their dairies—even though it is so inefficient. Why not? Japan produces rice. Rice is sort of the heartbeat of the Chinese tradition. But they also found out in the 1970s, when we had the energy crunch, that this other cereal called wheat, that had been forced upon them, though they liked it, but wheat coming in ships was curtailed because of the energy crisis. They were not getting the supplies that they had hoped for. That told them right there, that they had better be self-sufficient for their national interest. For that reason, I can agree with them.

We know that if you grow food outside, the [energy investment measured in] kilocalories (kcal) will be almost 4,000 per kilogram of fruit. But if you grow that in the conventional greenhouse, it's going to be 40,000 kcal per kilogram of fruit. Why? Because that heat and cooling take a lot of energy. So that's why we have spent so much time looking at putting blankets over the crop at night, to stop the heat from going out. The potential is that we can get that down to about 6,000 kcal per kilogram, versus 4,000 outside, through solar energy means, and alternative energy sources.

Here's the interesting thing. If I take that tomato and move it 2,000 kilometers by semi-truck, [it takes] 746 kcal per kilogram [to move it]. If I do that by railroad, it is 236 kcal per kilogram. And if I do it by airplane it is 4,500 kcal per kilogram to move it.

So you grow a tomato in a greenhouse—40,000 kcal. But I can truck it in from Mexico, for probably no more than 1,400 kcal. Look at the distance from the Mexican production areas to New York; I can grow it outside for very little kcal, and move it by truck.

That's why we have 50% of our produce in North America coming from Mexico. This is just looking at energy—not labor and the other inputs.

EIR: What if people want fresh, interesting food, locally and regionally produced? For example, if the Norwegians want their own cows, that's up to them.

Jensen: That's exactly up to them. And who worries about people if they are not getting enough of any one product? Who worries about them when there is a world crisis?

Another thing is, are you going to have all these [former farmers] move to the city? And then what do you do to subsidize those people? Do you subsidize them in a way of life that has been common to their culture for hundreds of years, or do you put them into a foreign environment and subsidize them there?