

## NUTRIGATION TO ENHANCE THE CROP YIELD BY SOLAR POWER

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### ABSTRACT

Yield of crop is the function of irrigation and nutrients. Nutrivation is a simple term coined two words nutrient and irrigation. Currently in spite of placing up modern irrigation (Drip/Sprinkler) system, growers (farmers) are still believing on more water means more yield rather than focusing on nutrient application and nutrivation efficiency. Means growers still following traditional way of fertilizer application to partially good & bad way of fertigation. There are number of equipment available for injection of fertilizers such as venturies, fertilizer tanks, dosing pumps, injectors mainly working at pressure differential principle engendered manually with certain constraints:

- Inconsistent mixing of nutrients in water resulted in leaching off valuable nutrients.
- Optimum pH & EC level of nutrients, resulting asymmetrical nutrient uptake rate.
- Toxicity increases in plant; this fact is normally ignored by many of us, if it goes beyond the limit, leads to formation of toxicity in plant, soil and ground water as well. One of the examples is soils in Punjab, Haryana, Maharashtra, and Gujarat has turned to sodic and hardly to grow any crops because of excess application of fertilizers.
- 30-60% wastage of fertilizers.
- Overall input cost increases significantly.
- Less Nutrivation efficiency resulted in substantial reduction in yield.

Solar Powered Nutrivation System (SPNS) plays important role to plug up the gap between irrigation and nutrients. In SPNS, nutrients are vaccinated along with irrigation water in pulses at desired pH & EC in order to match up the nutrient up rate of crop without creating the toxic effect to soil, water and plant. Photosynthesis process takes place in day time; obviously nutrients must be applied during photo period only along with irrigation water. Since solar radiation is harvested in day time, the entire nutrivation to crops has to be concluded in day time, to enhance the photosynthesis process which may result in faster growth and increase in yield. Required nutrients application is to be clubbed with irrigation demand of crops based on the fluctuation of solar radiation from morning to evening and season to season. The present article throws light on the use of Solar Powered Nutrivation System to increase nutrivation efficiency and enhancing crop productivity along with case study.

**Keywords :** Nutrivation, Nutrients, Solar powered, Drip, Sprinkler, EC, pH, Venturies

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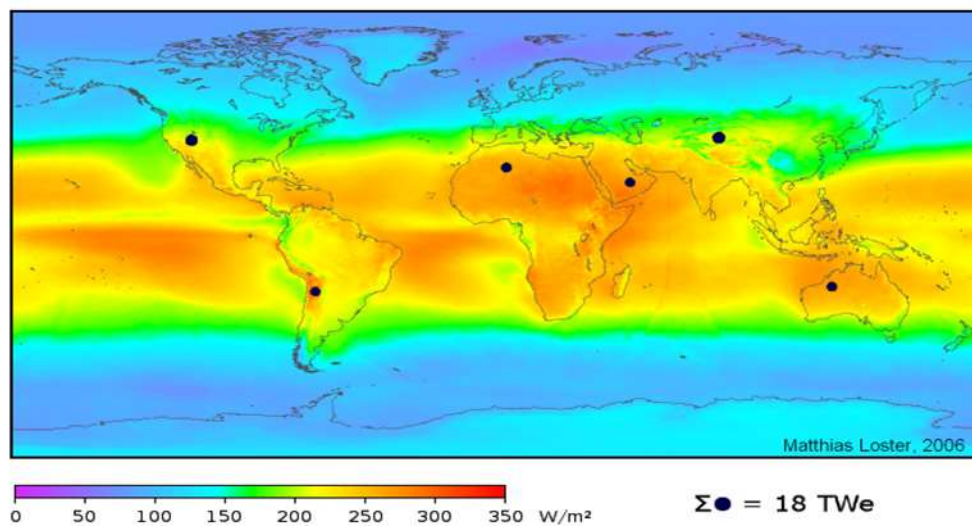
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## 1. INTRODUCTION SOLAR PHOTOVOLTAIC (PV)

The photovoltaic effect refers to photons of light exciting electrons into a higher state of energy, allowing them to act as charge carriers for an electric current i.e. solar cells convert sunlight energy into flow of electrons. The photovoltaic effect was first observed by Alexander-Edmond Becquerel (French Physicist) in 1839. The term photovoltaic denotes the unbiased operating mode of a photodiode in which current through the device is entirely due to the transduced light energy. Virtually all photovoltaic devices are some type of photodiode. Solar cells produce direct current electricity from sun light, which can be used to power equipment or to recharge a battery. The first practical application of photovoltaic was to power orbiting satellites and spacecraft, but today the majority of photovoltaic modules are used for grid connected power generation and domestic lightings.

Countries positioned across the equator have wide scope of harvesting maximum solar power @ 350 w/m<sup>2</sup> (figure 1 & table 1). Potential of solar energy decreases while proceeding towards north-south poles @ 3 to 5 % per degree of latitude. However, solar energy harvesting is dependent on temperature, relative humidity, clouds, latitude, longitude and obstructions at the particular location. Therefore, it is necessary to acquire the climatic data from nearest meteorological station. Base on meteorological data, potential of solar energy harvested can be estimated for design purpose along with solar module and allied equipment.



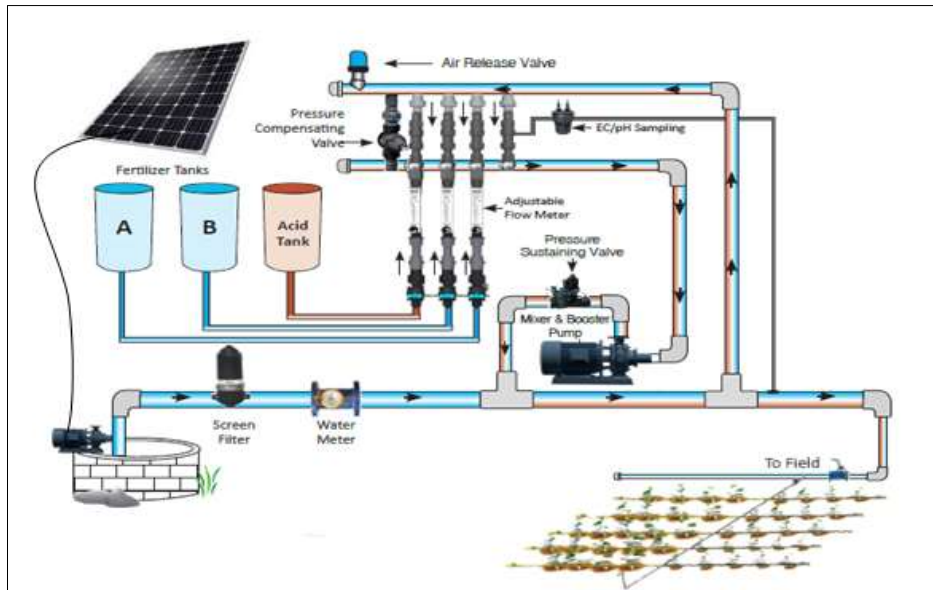
**Figure 1: Global Solar Power Available**  
(Twe = Terawatt – 10<sup>12</sup> watt)

## 2. SOLAR POWERED NUTRIGATION SYSTEM (SPNS)

In Solar Powered Nutrigation System, solar photovoltaic modules are being used to power motor pump-set of nutrigation unit in place of conventional electrical motor pump-set or diesel engine. Schematic layout of Solar Powered Nutrigation System, is shown in figure 2, comprising of Nutrigation Unit, Control Head Unit, Piping network, Driplines, Solar Photovoltaic Module, Control Panel and Motor Pump-set.

**Table: 1** Potential of solar energy for various countries given for reference only

Position	Countries	Solar Power (W/m <sup>2</sup> )
Near to Equator	Ecuador, Colombia, North Brazil, Gabon, Congo, DRC, Uganda, Kenya, Rwanda, Somalia, Maldives, Indonesia, Tanzania, South Sudan, Ethiopia, Malaysia, Central Africa, Cameroon, Nigeria, Ghana, Liberia, Sierra Leon, Burkina Faso, Senegal, Guyana, Venezuela, Costa Rica.	300-350
Near to Tropic of Cancer	Taiwan, Philippines, South China, Vietnam, Thailand, Burma, Bangladesh, India, Srilanka, Nepal, Pakistan, Afghanistan, Iran, Saudi Arabia, Iraq, Israel, Jordon, Syria, Egypt, Algeria, Tunisia, Mexico, Mauritania, Mali, Niger, Chad, Libya, Egypt, UAE, Oman, Myanmar.	250-300
Near to Tropic of Capricorn	Botswana, Brazil, Chile, Madagascar, Mozambique, Namibia, Paraguay, and South Africa.	250-300
Above Tropic of Cancer	Japan, North & South Korea, China, Turkey, Russia, Ukraine, Germany, France, Spain, Italy, USA, UK, Other European countries.	200-250
Below Tropic of Capricorn	Australia, New-Zealand, Argentina, Chile	200-250



**Figure 2 :**Schematic Of Solar Powered Nutrigation System

### 3. CONSIDERATION WHILE SELECTING SOLAR POWERED NURTRIGATION SYSTEM

Since solar radiation is available in day time, nutrigation to crops has to be concluded in day time to maximize the efficiency. Following factors needto be integrated with soil, water, and climate and crops requirement.

- Estimation of average solar radiation- morning to evening on monthly and seasonal basis.
- Optimization of ETcrop (Net Crop water demand) on daily, alternate and monthly basis.
- Soil based water retention capacity.
- Soil Analysis report – physical, chemical, biological parameters of soil.

- Existing nutrient level (N, P, K & micro nutrients) in soil.
- Water analysis report – physical, chemical parameters.
- Optimization of fertilizer dosages as per growth of crops.
- EC (electrical conductivity) & pH level of irrigation water, leachate and soil.
- Operation / management of system.
- Optimization of requirement of motor-pump-set (solar powered)
- Photovoltaic Solar Module.
- Master planning of crops.
- Techno-commercial parameters.

Salt tolerance and corresponding yield potentials of various crops are given in (Table 2). Yield of crop is directly proportional to salt tolerance limit. Nutrient uptake rate and required EC level of nutrients should be in between minimum & maximum limit of salt tolerance to maximize the yield shown in equation 1.

$$\text{Equation 1: Nutrient injection rate} = \text{EC of crop} \times \text{wrt} = \text{EC}_{(\min)} < \text{EC}_{(\text{require})} < \text{EC}_{(\max)}$$

(yield potential)

**Table: 2** Salt Tolerance and yield Potential of various crops

Field Crops	100%		90%		75%		50%		Max EC	
	EC <sub>e</sub>	EC <sub>w</sub>	EC <sub>e</sub>	EC <sub>w</sub>	EC <sub>e</sub>	EC <sub>w</sub>	EC <sub>e</sub>	EC <sub>w</sub>	EC <sub>e</sub>	EC <sub>w</sub>
Cotton	7.7	5.1	9.6	6.4	13	8.4	17	12	27	18
Sugar beet	7.0	4.7	8.7	5.8	11	7.5	15	10	24	16
Wheat	6.0	4.0	7.4	4.9	9.5	6.3	13	8.7	20	13
Soybean	5.0	3.3	5.5	3.7	6.3	4.2	7.5	5.0	10	6.7
Groundnut (Peanut)	3.2	2.1	3.5	2.4	4.1	2.7	4.9	3.3	6.6	4.4
Rice (paddy)	3.0	2.0	3.8	2.6	5.1	3.4	7.2	4.8	11	7.6
Sugarcane	1.7	1.1	3.4	2.3	5.9	4.0	10	6.8	19	12
Corn (maize)	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10	6.7
Squash, zucchini	4.7	3.1	5.8	3.8	7.4	4.9	10	6.7	15	10
Broccoli	2.8	1.9	3.9	2.6	5.5	3.7	8.2	5.5	14	9.1
Tomato	2.5	1.7	3.5	2.3	5.0	3.4	7.6	5.0	13	8.4
Cucumber	2.5	1.7	3.3	2.2	4.4	2.9	6.3	4.2	10	6.8
Cabbage	1.8	1.2	2.8	1.9	4.4	2.9	7.0	4.6	12	8.1
Potato	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10	6.7
Pepper	1.5	1.0	2.2	1.5	3.3	2.2	5.1	3.4	8.6	5.8
Lettuce	1.3	0.9	2.1	1.4	3.2	2.1	5.1	3.4	9.0	6.0
Onion	1.2	0.8	1.8	1.2	2.8	1.8	4.3	2.9	7.4	5.0
Carrot	1.0	0.7	1.7	1.1	2.8	1.9	4.6	3.0	8.1	5.4
Alfalfa	2.0	1.3	3.4	2.2	5.4	3.6	8.8	5.9	16	10
Date palm	4.0	2.7	6.8	4.5	11	7.3	18	12	32	21
Orange, Lemon	1.7	1.1	2.3	1.6	3.3	2.2	4.8	3.2	8.0	5.3
Grape	1.5	1.0	2.5	1.7	4.1	2.7	6.7	4.5	12	7.9
Strawberry	1.0	0.7	1.3	0.9	1.8	1.2	2.5	1.7	4	2.7

- Source: FAO Publication 24. (These data should only serve as a guide to relative tolerances among crops. Absolute tolerances vary depending upon climate, soil conditions and cultural practices)
- EC<sub>e</sub> means average root zone salinity as measured by electrical conductivity of the saturation extract of the soil, reported in deciSiemens per meter (dS/m) at 25°C. EC<sub>w</sub> means electrical conductivity of the irrigation water in deciSiemens per meter (dS/m). The relationship between soil salinity and water salinity (EC<sub>e</sub> = 1.5 EC<sub>w</sub>) assumes a 15–20 percent leaching fraction and a 40-30-20-10 percent water use pattern for the upper to lower quarters of the root zone.

**Table 3:** Various grades of 100 % water soluble fertilizers

Grades of fertilizers	Composition
Urea Phosphate	17.44.00
Sulphate of potash (MOP)	0.00.50
Urea Phosphate with SOP	18.18.18
Potassium Nitrate	13.00.45
Mono Potassium Phosphate	00.52.34
Mono Ammonium Phosphate	12.61.00

#### 4. PROCEDURE TO USE SOLAR POWERED NUTRIGATION SYSTEM

Following steps shall be followed while using Nutrigration System

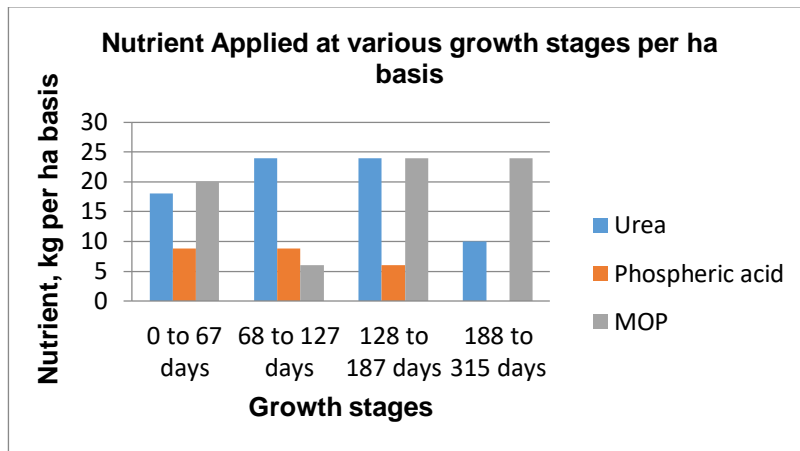
- Step 1. Soil analysis report: Test for EC, pH, N, P, K & micro nutrient level in soil.
- Step 2. Water analysis report: Test for EC, pH and TDS level in irrigation water.
- Step 3. Leached water analysis report: Test EC & pH of leached out water after 24 hours.
- Step 4. Determine the fertilizer dosages and grades of fertilizers as per crop growth stages.(Various grades of 100% water soluble fertilizers (Table 3) are available in the market.)
- Step 5. Adjust the pH of fertilizers as per details provided by Fertilizer Company.
- Step 6. Determine the limit of toxicity from Table 2.
- Step 7. Make the stock solution of fertilizer in tank. A,B,C....etc.
- Step 8. Set the value of EC & pH at Nutrigration Unit program.
- Step 9. Switch the nutrigration system.
- Step 10. Monitor the level of stock solution in fertilizer tank.

#### 5. PRECAUTIONS

- Soil based water retention capacity should be increased by adding soil conditioner and organic manure to avoid the risk of depleting moisture level beyond wilting stage of crops even though there is gap of irrigation.
- Sufficient water application should be made to meet the water demand of crops in the day time in the available solar radiation.
- All fertilizer should be 100 % water soluble.
- Design of micro irrigation components i.e. piping network, filtration system and driplines etc. should be adequate and harmonized to cope up the demand of crop at fluctuated solar radiations on daily and seasonal basis. In other word design of nutrigration system has to be harmonized with harvested solar power (radiation) to meet the crop water demand.

## 6. CASE STUDY: SOLAR POWERED NUTRICARE SYSTEM

Sr	Parameters	Details
<b>A</b>	<b>Under Nutrigation System</b>	
1	Farmer	Mr RajaramGunu Mahajan
2	Location	Tamaswadi, Raver- Waghoda Maharashtra India
3	Area under Banana	5 ha
4	Crop	Banana
5	Variety	Tissue Culture - G-9
6	Spacing	1.8 m X 1.5 m
7	Nos of plants	18,000
8	Date of plantation	20th June-july 2015
9	Method of plantation	Ridges and furrow
10	Date of harvest	May 2016 (after 11-12 months)
11	Irrigation System	Drip Irrigation,dripline 16mm, dripper 4lph at every50 cm
12	Fertigation	Jain Solar Powered Nutricare
13	Soil Type	Clay loam
14	Fertilizer applied	Water Soluble Fertilizers
a	0 to 67 days	Urea - 90 kg
		Phosphoric acid -50 kg
		MOP - 100 kg
b	68 to 127 days	Urea - 120 kg
		Phosphoric acid -50 kg
		Magnesium Sulphate -30 kg
		MOP - 120 kg
c	128 to 187 days	Urea - 120 kg
		Magnesium Sulphate -30 kg
		MOP - 120 kg
d	188 to 315 days	Urea - 50 kg
		MOP - 120 kg
15	Yield	Banana Bunch -35 kg per plant (average)
		175 ton (average)
16	Water applied	1600 mm per ha
<b>B</b>	<b>Same farmer used to do under conventional fertilizer previously but under drip irrigation system</b>	
1	Yield	Banana Bunch - 16 kg per plant (average)
		80 ton
2	Water applied	1800 -2000 mm per ha
<b>C</b>	<b>Result</b>	
1	Increase in yield	118%
2	All other benefits of micro irrigation ie.water saving, fertilizer savings, power savings, labour cost savings etc achieved.	



## 7. CONCLUSION

It has been seen that most of the growers and institutions (Government & Private) are just centring on water management methods to conserve the water, being a national asset by promotion of micro irrigation system, on other hand they are underestimating nutrification applications, which plays pivotal role in assessing of crop productivity – viability per unit of power, water, input & investment. Therefore, Solar Powered Nutrification System (SPNS) is worthwhile to address all above issue and growers can do viable commercial farming in all ways.

## REFERENCES

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