

# Enhancing N, P, K and Green Water use Efficiency in Paddy by Application of Zn and S, Assuring Production of Quality Food with Reductions in GHGs Emissions and Carbon Foot Prints

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**Abstract** –Application of macro plant nutrients viz N, P, K is in common usage by the farmers in world over agriculture. However, needs of zinc and sulphur, the micronutrients, have been realized in recent decades. Farmers apply doses of zinc and sulphur in paddy crop grown largely field submerged with ponded water. However, chemistry of zinc and sulphur is still not well understood for their application for paddy crop cultivation, in particular. Applications of zinc and sulphur in submerged field condition which follow the anaerobic path, produce Zinc Sulphide and hydrogen sulphide, which act as poisons; detrimental for the crop and harvest remain without anticipated benefits. This article is devoted to deal with refinements in the nutrient management in paddy cultivation based on innovative application of the scientific facts, both macro and micro nutrients. This study brings new modifications in paddy cultivation which eliminates blame of environment pollution and put pressure of reducing area under submerged paddy.

The study presented scientific basis for nutrient applications and emphasizing cultivation of upland rice. In this practice the study recommends one fourth of nitrogen supplement by organic manures, ideally through aerobically decomposed compost (NADEP) and remaining three fourth by inorganic fertilizers. The carbon cycle, nitrogen cycle and sulphur cycle based nutrient management and inter cropping manifested practice reduce the GHGs emission thus, reduce atmospheric loads. Among several practices working under aerobic cultivation, racy (smart, alive and enthusiastic) nature agriculture stands as an ideal practice to bringing high and sustainable yield of paddy. Several innovative developments in component operations of the racy nature viz nutrient management and intercropping create new opportunity of enhancing yield and reduction of blame of environmental pollution and imposing restriction for extensive cultivation of paddy. Thus, the present study creates new breakthrough in agro-hydrology as non structural measures for overcoming vagaries and ravages of climate change for paddy production.

**Keywords** – Enhancement in Yield, Harvest Index, NPK and Water Use Efficiency, Macro and Micro Nutrient, Paddy Cultivation and Sulphur Cycle.

## I. INTRODUCTION

The paddy is major food crop grown in semi arid, sub humid and humid climate condition, where moisture availability is plentiful during the rainy season. India ranked first in area under paddy (41.66 million ha) and second in terms of total production (85.31 million tonnes), stood next only to China. The United Nations General Assembly

presented these details during International rice year during 2004-0. But, the yield levels in India had been low at 2.05 tonnes/ha, as against the yield levels of many rice producing countries. viz Japan 6.52 tonnes/ha, China 6.24 tonnes/ha and Indonesia 4.25 tonnes/ha. Paddy is transplanted crop and no gaps occur, thus, every part of field contributes yield, making high yield. It implicates that the paddy production technology [1] is inappropriate, in general and in India in particular, there exists large scope for improvement. It requires management technology based on scientific principles to bring enhancement in yield]. The enhancements in paddy yields will be able to supplement global food requirements [2].

In the contemporary agriculture soil is accepted as habitat [3] for providing all essential elements necessary for the plant growth, maintaining biodiversity and providing condition suitable for chartering water and environment interaction to produce nutrients in the form useable by plants. The demand of production and output has increased irrespective of low concern input management [4]. Thus, varied conditions have resulted in variety of problems of development of toxic salts and toxic gases [1], [5]. These impurities have resulted in degraded condition of the soil habitat and processed products ready for plant uptake that enter in food chains and cause several health hazards [5]. The habitat acquires characteristics of ecology as dynamic build up of production and consumption makes it an ecosystem [6]. The excessive withdrawal of output from the ecosystems results in misbalance in the ecological setting that adversely affects production capacity and sustainability. Since demand of food is constantly increasing, it requires maintaining the habitat supply and management to cope up to the requirement of plants to produce sufficient primary productivity [3].

The plants mainly require 14 nutrient element which form different ionic compounds by water and environment interactions that can be absorbed through the root hairs. **Table 1** contains the essential element and their chemical characteristics [7], [8] involved in the water and environment interactions. The elements N,P,K are the macro nutrients, Mg, Bo, S and Zn are micronutrients, Fe, Mn, Zn and Cu are the heavy metals. The elements O, and H are major chemical reaction chartering elements. The carbon C is synthesized in photosynthesis to produce carbohydrate (CH<sub>2</sub>O), although C keeps revolving in its own cycle [9]. In agriculture earlier, management practices

rested on management of macronutrient viz. N, P, K for long time [6]. In the past three decades the yield declines have lead to realization of need of micronutrients viz Zn in most of soil regions. The importance of the micronutrient S had been provoked for similar period as of the Zn in arid and semi arid soils, particularly, in sandy loam soils used for intensive cultivation of S loving crop viz mustard. However, no simple and practical method of overcoming deficiency of Zn and S had been known. In the present decade farmers apply Zn and S to major crops such as paddy, wheat and maize etc. Nevertheless, the chemistry involving water and environmental interactions still largely needs reappraisal. In the academic pursuits the knowledge on Zn is coming up, but that of S is still not found [10], [11], [12]. Only elemental sulphur is being applied in combination with N. The benefits from application of the micro nutrient Zn and S cannot come to the expectations due to bad chemistry that develops in water and environment interactions. It needs some innovative application of scientific facts of environmental chemistry and environmental engineering, which are not of common existence. The objective of the present study was to clarify, elucidate and substantiate certain relevant water and environmental interactions and appraise of accordingly devised innovative methods for management of macro and micro nutrients viz. N, P, K, Zn and S for paddy cultivation

technology could emerged [1],[11]. So far scientific strategies have been based on balanced use of the plant nutrient based on soil test/ analysed by the samples collected from the fields and analysed in soil testing laboratories worldwide. In the present study a new pattern of nutrient mangament in agriculture is reported that involves enforcement of nutrient cycle to work in the year round cropping [6], [9] [12]. As depicted in **Table 1**, N is the most prominent element involved in crops followed by P and K as major macro nutrients. The micro nutrients, where deficiency has been perceived are Zn and S. In the following the cycles of these essential elements are dealt with to enable understand the chemesty of nutrients, water and environment interaction, which restrict/support the production and release of the green house gases (GHGs).

## 2.1 The Scientific Facts

### 2.1.1 The N Cycle

**Fig 1** depicts the N cycle in environment and below the soil [10] [12]. Atmospphere contains nitrogen in gaseous stage about 78% of total gases by PPV. It reaches to the ground only by two ways viz nodulations built by cyno bacteria in the leguminous crops, and second by thunder and rain in the nitrate form. There are also evidenses that some non leguminous plants also fix nitrogen., nevertheless the the N cycle depicted by the Fig 1 is applicable for both types of N fixations. The N chemistry in volves several processes. In soil the processes are the ammonification, nitrification, denitrification, mineralization and immobilization.

Earlier studies by the author involved discretization and elaboration of the process and management practices [10], -- [14] The process of ammonification, nitrification and denitrification are conducted by nirofying and nitrifying bacteria. The strategy should be to keep the nitrogen reserve in soil to be minimum, by means of management that will minimise N loss through nitrous oxide, leachate in deep percolation and wash off in runoff. Nodulation is more when there occurs sufficiency of nitrogen and it adds  $RNH_3$  [15] the submerged land condition creates Nitrite which is in unuseable form; in order to keep its formation at its minimum level the land should be well drained, that justifies effectiveness of aerobic paddy and alternate wet and dry (AWD) condition creating irrigation [16]. The nitrogen mineralisation and immobilisation are induced by aeration created by ploughing during intervening periods. Thus, it requires complete understanding of water and in environmental interaction of N in paddy cultivations. Earlier studies have been on single subject and implications of N cross cuts in many direction. These, facts substantiate justification of crop diversification in paddy fields.

**Fig 1** presented in sudy serves as point of reference for time to time during the readership of the article. Various practices will reduce N application from external sources. It will also reduce emission of nitrous oxide ( $N_2O$ ) from the paddy fields [15], [17]. The western countries blame and reason the paddy cultivation in India as main contributor of methane and the nitrous oxide. They put pressure to reduce hectarage of area under paddycultivation to cut down the GHGs emission that causes global warming.

Table 1. Elements needed for plant growth.

S. No	Element	Symbol	Atomic weight	Common valance	Equivalent weight
1	Nitrogen	N	14	3 <sup>-</sup>	-
2	Phosphorus	P	31	5 <sup>+</sup>	6.0
3	Potassium	K	39.1	1 <sup>+</sup>	39.1
4	Calcium	Ca	40.1	2 <sup>+</sup>	20.0
5	Magnesium	Mg	24.3	2 <sup>+</sup>	12.2
6	Iron	Fe	55.8	2 <sup>+</sup>	27.9
7	Manganese	Mn	54.9	2 <sup>+</sup>	27.5
8	Boron	B	10.8	3 <sup>+</sup>	3.6
9	Sulphur	S	32.1	2 <sup>-</sup>	16.0
10	Zinc	Zn	65.4	2 <sup>+</sup>	32.7
11	Copper	Cu	63.5	2 <sup>+</sup>	31.8
12	Hydrogen	H	1.0	1 <sup>+</sup>	1.0
13	Oxygen	O	16.0	2 <sup>-</sup>	8.0
14	Carbon	C	12.0	4 <sup>-</sup>	-

Equivalent weight (combining weight) is equal to atomic weight divided by valance [9].

## II. MATERIALS AND METHODS

The agriculture involves scientific facts of biology that implicates nutrient uptakes, and supply in the soil habitat, it involves knowledge of principles of hydrology, ecology, environmental sciences and environmental engineering. Authors several studies [12] [13] [14] [15] reported detailed aspects of these scientific facts. Some of these scientific facts are popularly known, however, the aspects of cycles of some plant nutrient elements still need effective manoeuvre, that lead to the facts that no innnovative



Fig. 1. Nitrogen cycle after [10] and update by author.

### 2.1.2 The Sulphur Cycle

The sulphur cycle (Fig 2) displays process involved in decomposition of cellulose which is a crude form of protein, in to sulphate or sulphide depending on the oxygen supply [10],[11],[12] in the medium of decomposition. Plants and animal residues and organic residue protein are acted upon sulphur bacteria and under the prevailing condition of aerobic or anaerobic sulphate or sulphides are produced. Under un polluted water condition the sulphide is converted in to sulphate again [9]. Sulphate is used by plants in producing chlorophyll, building tissues [11], [12]---[18]-harvest index [12].

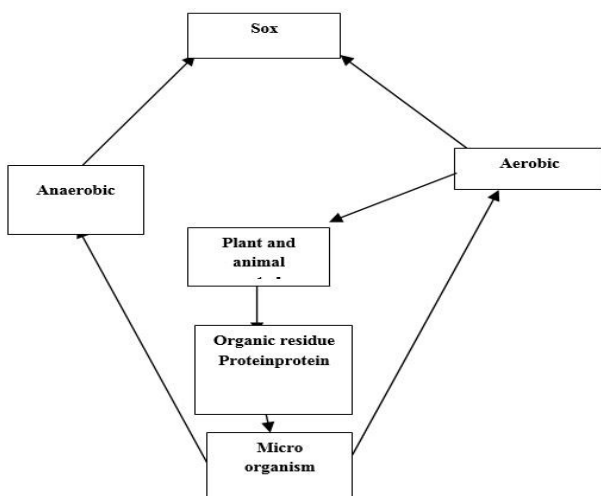


Fig. 2. Sulphur cycle [10].

### 2.1.3 Zn Cycle

The chemistry of zinc is similar to that of sulphur, particularly when zinc is applied through zinc sulphate and resulting effects on crop contributing factors [18], [19]. The conversion of zinc sulphate in to zinc sulphide becomes yield deterrent. Hence, efficacy of zinc sulphate is visible under aerobic conditions. Thus, in the submerged land

paddy benefit from the zinc sulphate is least likely to occur [11].

### 2.2 Experimental Studies

Experimental results on Zn and S application were selected from the suitable published researches adopted to substantiate the application of scientific facts which became basis for suggesting improvement in the ongoing practices. Based on substantiation the result based, package of practices was devised to enhance yield of paddy and that for following winter season crop of the year, largely wheat representing beat cropping practice in the Indo-Gangetic belt, featured as food basket, in north India.. Results and discussion are focused to justify all dealing in the manuscript. The two very relevant experimental results are referred to illustrate the working of scientific facts for Zn and experiment II elaborating the role of nitrogen and S.

#### 2.2.1 Experiment I

This field experiment reported cited here perfectly support the hypothesis dealt with. The study was conducted during 2004-05 on wheat and rice in Pakistan to study the response of Zinc application in wheat-rice system [20]. Two levels of zinc 5 and 10 kg/ ha with control, were studied with the basal dose of N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O as 120-90-60 kg/ ha in the form of urea, TSP, SOP and zinc sulphate during both the crops of rice and wheat. Wheat variety Naseer 2000 and rice variety IRRI 6, both were planted in R.C.B design with three replications.

#### 2.2.2 Experiment II

Like in Experimental Study cited I this study equally supported the hypothesis on efficiency of S.. The various nitrogen sources used were: urea, ammonium sulfate, calcium ammonium nitrate (CAN) and ammonium nitrate (AN) [21], [22]. In this study Nitrogen was applied @ 100 kg/ha in two splits (half at transplanting and half at booting stage). Basal dose of P and K were applied each @50 kg/ha as single super-phosphate and potassium sulfate, before transplanting the nursery plants of rice variety IR-6. Application of ZnSO<sub>4</sub> @ 10 kg/ha was added in the following sequence:T1 100 kg N/ha as urea, with no zinc,T2 100 kg N/ha as urea with 10 kg ZnSO<sub>4</sub>/ha.T3 100 kg N/ha as ammonium sulfate, with no zinc.T4 100 kg N/ha as ammonium sulfate, with 10kg ZnSO<sub>4</sub>/ha.T5 100 kg N/ha as calcium ammonium nitrate(CAN), with no zinc.T6 100 kg N/ha as calcium ammonium nitrate(CAN), with 10 kg ZnSO<sub>4</sub>/ha T7 100 kg N/ha as ammonium nitrate (AN)

As a necessary elaboration, described here is the racy nature agriculture and implications of nitrogen cycle in paddy based cropping. Innovative practices are drawn for the rice based agriculture.

## III. RESULTS

### 3.1 Effect of Zinc Application on Rice Yield Under Wheat Rice System

This study [20] indicated the facts that Zinc application of 5 and 10Kg/ha enhanced yield of wheat in wheat rice system. The dose of Zn has to be applied as a supplementing micronutrient dose in paddy wheat cropping system. The Zn is applied through Zn sulphate in all the treatments as basal dose before transplanting. Zink accumulates in soil as a

result of residual Zn left by the preceding crops. Recommended dose of Zn sulphate was 10 kg/ha for both the crops independently.

### 3.2 Effect of N sources and Zn for Paddy Irrigated with Distilled Water - Pot Experiment.

Table. 2. Effect of nitrogen sources and zinc on paddy grain, straw yield and paddy: straw ratio [22].

Treatment	Paddy yield Straw yield(g/pot)		Paddy : Straw ratio
	Paddy	Straw	
T1 Urea	36.1	47.4	0.72
T2 Urea +zinc Su	46.1	53.3	0.87
T3 Ammon Su	39.9	51.2	0.76
T4 Amm S+Zn S	49.9	58.4	0.91
T5 CAN	34.5	45.8	0.75
T6 CAN +ZnS	41.0	49.7	0.76
T7 AN	33.5	45.5	0.68
T8 AN +ZN S	39.8	49.6	0.749

Means sharing the same letter (s) are statistically non-significant at < 0.05 probability.

All N sources were applied 100kgN/ha,

All plots were irrigated by distilled water.

### Zn S : Zinc Sulphate

As it was established theoretically, the application of zinc and S with distilled water the hydrogen sulphide and zinc sulfide get converted to sulphate and zinc sulphate, hence it showed increase in the harvest index for T2 and T4. For crop growing with rain water the zinc and sulphur become effective and harvest index increases. Thus, water pollution by any means will produce poison and adversely affect yield of paddy under submerged condition. Thus, depending on source of irrigation water the utility of Zn and S supporting fertilizer should be considered.

Urea as N source is the best suited for paddy because of its split application eliminates loss of N by deep percolation. For paddy Zn should be applied as basal dose in combination with the nitrogenous fertilizer. Zn use efficiency is more for wheat than for paddy. It will be better to apply Zn for wheat and get advantage of residual Zinc in paddy field. It is implied that supplementation of NADEP composting [12] will add some Zinc that will fulfill need of Zn for paddy and there may be no need to apply Zinc for paddy in submerged condition.

Thus, the two experiments clearly established the pattern of micronutrient application Zn and S. This information will enable adopt beneficial practice and reduce cost of application of Zn and S. Aerobically decomposed compost will be highly suitable and reduce cost of cultivation of paddy.

### 3.3 Implication of Chemistry of S and Zn

As the chemistry of S and Zn follow different routes under submerged and aerobic condition (Fig 2), it produces useful and harmful products. These two routes are aerobic and anaerobic, which produce Zinc sulphate under aerobic ie not submerged but wet but aerated condition. Under the submerged condition the oxygen is absent and the chemistry follows other route of anaerobic decomposition that produces hydrogen sulphide and Zn sulphide. These

two products cause damage to the paddy plants. Therefore, the anticipated benefit of S and Zn application will not accrue for the submerged paddy crops, especially when water is having any kind of pollution [21]. There will occur drying of paddy plants in submerged land paddy where Zink is applied. This indication is like *khaira* disease in paddy. It needs conducting aerobic cultivation of paddy, which can be acquired in three following forms.

Researches [24], [25], [26] revealed that rice is deficient in vitamin A, Calcium and iron, which have important nutrient impact on quality of rice as a staple food. The lack of thiamin and tryptophan causes some inadequacy of healthy nutrition. Therefore, some diversification of crops had always been desirable. Studies [27], [28] were carried out to bring some crop diversification; it could not be successful under some conditions. The raised bed and furrows system was experimented [27], [28] specially for creating diversification in cropping where paddy had been cultivated as the sole paddy crop under submerged field condition, viz south east Asia and Eastern and southern India. However, in those studies endowments of nitrogen cycle and sulphur cycles were not done then and additional need of heavy power it could not get widely adoption. But same raised bed and furrow (Fig 3a, b) is now supported by many innovations on all aspects of activities, hence the limitations of those times are sufficiently removed. The RBF system is planted with inter cropping, which is an ideal cropping pattern for providing ideal food commodities for nutrition menu. A reference is made of recent report [29] that nutritious food reduces carbon food print. In the report combination of fishery product, which thrives on indispensable water, increases nutrition without additional dispensable use of water. In the present study an innovative cropping practice [30] [31] is presented, which will be growing with rice, whether low or high rain fall and provide agriculture commodity with minimum need of pumping for irrigation application and produce good quality food. The upland rice will mature with rain water. The practice of upland rice accompanied by inter cropping of N fixing crop will improve quality of food commodity, reduce emission of GHG CH<sub>4</sub> and N<sub>2</sub>O etc. thus use of rainwater and intermittent drying condition will enable N fixation that will enhance yield and reduce emission of GHGs, necessary for reducing carbon foot print. Further, dealing in this direction is focused on various ways in which upland paddy cultivation can be conducted.

#### 3.3.1 Upland Paddy Crop

The upland paddy cultivation is carried out in the low lands getting run off from the fields above it, because of availability of water in rainy season is more than crop's requirement, farmers can utilize it for cultivation of paddy, because of superior quality of food grain; soft to eat, uniform growth, tolerance to occasional flooding and relatively higher yields / ha than other rainfed crops. This paddy cultivation should be for short duration variety and directly seeded and early maturing so that next crop of winter season is sown on time. The main problem has been the intensity of weeds and inadequacy of physiological development of tillering in paddy. Later on people have resorted to transplanting this type of variety for upland rice.

As there is always intermittent flooding and drying, there exist wet and upland conditions. New pattern of rice cultivation has been given a scientific name ie aerobic paddy. Although, it becomes a craze to give high sounding name, but again it is term used with respect to decomposition process, which occurs in presence or absences of oxygen. Since this aspect and related chemistry is not well comprehended for cultivation of rice, the new name is not fulfilling all the requirements and scientists aim capitalizing new sounding word of paddy cultivation for well known and practiced by the Indian farmers. This aspect of paddy cultivation is displayed by [19].

The upland paddy cultivation is a compulsion and to some extent utilization of situation of low land for cultivation. There occurs saving in water and productivity enhancement due to uniform stand of paddy from all part of field under the crop.

### 3.3.2 Irrigation Water Managed Crops by Alternate Wetting and Drying (AWD)

In the countries with temperate climate, scientist aimed at reduction of water need for cultivation of paddy. In this practice of alternate wetting and drying there is proportionate saving in volume of water. But, the earlier researchers [21] got afraid of again use of this saved water for cultivation of Boro paddy in most of rice eating states in the Eastern India. The Boro paddy is again blamed for high contribution of methane and nitrous oxide releasing practice for production of rice. The intermittently irrigated and dried field condition will go in better way and will eliminate danger of emitting GHGs. The alternate drying period is considered as providing sufficient opportunity to reduce GHGs emission from the paddy fields. This AWD is basically for aeration of soil profile that creates condition at par with aerobic paddy cultivation, it eliminates need of paddy puddling.

The AWD eliminates continuous flooding that avoids for some time of growing season of rice emission of CH<sub>4</sub> under the continuous flooding. The AWD simulates condition of upland rice where water floods the paddy fields when it rains and gets to drier condition. That means the emission of CH<sub>4</sub> is eliminated to considerable extent. Under climate changing situation the pattern of rainfall is getting disturbed, hence the situation will tend to reduce CH<sub>4</sub> emission, but rice cultivators normally hesitate and get conscious for not to take risk of likely unsuccessful harvest of rice crop. Further, when N is applied to paddy it emits nitrous oxide when it is submerged. Keeping paddy under the aerobic condition the emission of the N<sub>2</sub>O will be reduced. Further, an invention has been created named as zero weeding agriculture, ie with this practice the problem of crop loss by weeds get eliminated and additional nitrogen fixation enhances yield of crop viz rice under aerobic condition of the upland rice. The nitrogen fixation and simultaneous utilization by the paddy plants will keep N reserve in soil low that will keep the emission of the N<sub>2</sub>O low. The paddy cultivation is blamed for enhanced CH<sub>4</sub> and N<sub>2</sub>O emission and according to the analysis of the environmental defense Fund in the U.S both methane and Nitrous oxide from rice farms could have the same long term global warming impact as about 600 coal plants [21].

Thus, AWD or upland rice cultivation with innovative technology of weed management i.e. zero weeding agriculture will enhance yield and simultaneously reduce both the GHG emissions. Further, researches have indicated that CH<sub>4</sub> and N<sub>2</sub>O are precursor of ozone (O<sub>3</sub>), which a secondary GHG, which causes variety of health hazards, particularly lung cancer. Thus, the upland rice cultivations where water is available will fulfill both the objectives of enhancements in yield and protection of environment. This is wonderful and simple adoptable solution of containing the GHG [14], thus, blame that paddy cultivation is highly responsible for global warming is overcome by new invented technology [14]. Since during the rainy season uplands suffer problems of splash, rill and surface runoff erosion, the entire problem of the erosion is controlled by the upland rice cultivation as fields are leveled well vegetated at surface runoff retained in field. The rice crop should be sown with leguminous inter crop that will fix nitrogen and enhance field of upland rice. In the event of failure of rainy season will be quite enough to produce pulse crop which requires less water. Advantage will be reduction of soil erosion, reduction of GHG CH<sub>4</sub> and N<sub>2</sub>O as well as O<sub>3</sub>. The soil health will get improved and its impact will be reflected by enhanced yield of following winter season crop via wheat. Thus, these innovative researches enhance utility of AWD aimed at enhancing water productivity.

### 3.3.3 Submerged/Pounded Water Paddy Cultivation

The submerged /pounded field paddy cultivation is an old practice, with advantage of weed control and harness occasionally available or largely flooded fields. The average yields in India are far lower than those in Japan and China. The fields under paddy are utilized for wheat cultivation. Paddy – wheat is very established cropping pattern in most of paddy and wheat cultivating states in India. The high demand for both water needing crops have become reason for withdrawal of ground water for irrigation leading to deepening of ground water table. The deepening of ground water table is a vast topic in itself and many documents are available on this issue. Water conservation became necessity of the time and several new innovations have emerged which are briefly described in the following sub heads. However, paddy cultivated by irrigation water is less preferred than the rice produced with green (rain water) as many quality characters are not so acceptable (Yana, 2015). This, fact justifies why upland rice utilizing green water should be popularized.

### 3.3.4 The System of Rice Intensification (SRI)

The system of rice intensification (SRI), developed in Madagascar in early 1980s by Father Hen ride Lausanne, a Jesuit Priest, who spent over 30 years working with farmers in that country. The SRI is basically a plant physiological innovation based technology [12]. Young seedlings of 10-12 days old are transplanted in high density (22 cm x 22 cm grid), while the water submergence, fertilizers, manure and some agronomical practices are flexibly at par with the other earlier known practices. Cultivation is carried out where no prolonged flooding is maintained so anaerobic decomposition is eliminated from the system. The SRI method can be said on the basis of its cultivation after planting to fulfill requirement for the operation of the

sulphure cycle. System uses compost in nursery preparation, which releases methane and includes no simple way of supplementing sulphure (S), an important plant supporting nutrient. Application of aerobically decomposed composts will make it a true scientific fact based method of universal application for rice cultivation for bringing sustainable agriculture and protection of environment. The extensive researches are being conducted on SRI in the world, wherein by now > 300 research articles have been published. Thus, need and scope are emerging for conducting scientific evaluation of these researches to know the scientific sufficiency so as to enable bringing further innovation in paddy production. So far the results that came to notice during the present study SRI have shown 10-15% increase in the yield of paddy over that of conventional method of paddy cultivation. Further, yield potential is to be contrasted with that of flooded paddy cultivation in low land condition.

Water regime has been researched upon and so was the issue of methane release. The yields have increased due to prolonged growing period and high density plant bearings seeds/ exhaustive tillrings. Thus, the SRI is not a complete green technology. Study [12], [22] made suitable recommendations to improve module to make the SRI a green technology of paddy cultivation.

### 3.3.5 Stranding

A new plant physiological practice [12] is emerging in which plants raised in nursery are removed and planted in another field where they get stiffened and acquire capacity of profuse tillerings. This new aspect has been in the Eastern U.P and farmers are getting convinced by the tillering and grain filling resulting in enhancement of paddy yield. However, it has yet to receive scientific research attention.

All the aforesaid practices have been going on, which can be considered some kind of advancement. But there is no any better improvement in the nutrient management in paddy cultivation. Thus, in spite of efforts and practices there has been no remarkable gain in yield of paddy. The water savings so far achieved are yet to convince large scale adoption. In the mean time the climate change and global warming is coming as impediment in enhancing yield of paddy. Thus, there is still better use and effort to bring breakthrough in paddy cultivation.

### 3.3.6 Racy Nature Agriculture Practice.

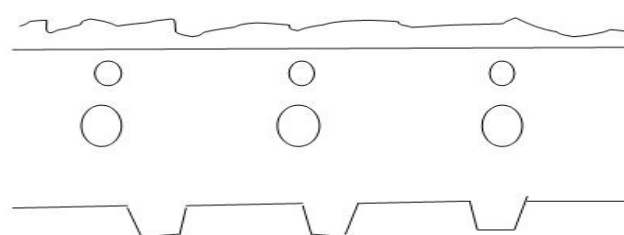
The racy (smart alive and enthusiastic) nature agriculture technology has been developed by innovative application of scientific facts of biological sciences, hydrology, physiology, chemistry, environmental sciences and environmental engineering [14], [15] which shine as sun technology and characterising quantum agriculture [15]. The technology considers all aspects of nutrients (organic and inorganics), bed configuration, sowing/ transplanting for precision stand establishment, irrigation, weeding, inter culture, harvesting and post harvesting on the basis of year round cultivation for bringing enhancement in yield). The technology components fulfill all aspects of nutrient up take, oxygen supply to cope up with requirement of biodiversity, moisture supply, weed control, insect pest control, and harvest and post harvesting technology to

reduce need of costly work of tillage and reduction of emissions of GHGs.

Table 3. Conservative assessment of yield enhancement by racy nature agriculture practices components and their justification [15]

S. No	Racy nature agriculture practice component	Possible increase, %	Aspects of optimizations
1	Aerobically decomposed manure, (NADEP) application	15	The one fourth of nutrient N should be supplemented by organic manures.
2	Ploughing	5	Ploughing creates aeration that convenes aerobic decomposition
3	Formation of raised bed and furrow system	10	It increase soil depth to larger volume of moisture and air in the root zone.
4	Application of activated charcoal for bio remediation	Improved quality	Heavy metals such as iron, zinc, manganese, and copper and chlorinated organics get absorbed by the activated charcoal.
5	Precision sowing	5	The precision sowing enable harness yields from entire space of the field under crop.
6	Maintenance of optimum plant density	10	Optimum plant density will bring vertical growth and yield.
7	Establishing zero weeding pulse based ecology	5	It will save nutrient and moisture removed by weeds
8	Ultimate green irrigation	10	Sprinkler irrigation produces green water and saves irrigation water volume.
9	Weeding	-	No weeding will mean toil free agriculture.
10	Inter culture	10	It will enhance aeration during the crop growth in the field.
11	Subsequent cropping system	5	Post-harvest cultivation will reduce at least 10% of total yearly GHGs emission.
12	Infrastructure for crop drying	To be assessed	An innovative pyramid roof top building developed to creat built space for protection from aberrant weather and crop drying.
13	Composite enhancement additive index	75	Combined additive effect of all factors enumerated above.
	Multiplicative index	2.047	Combined multiplicative effect of above all factore
	Average	1.8985	$(1.75 + 2.047)/2 = 1.8985$

### Technology Module Clouds and Rain

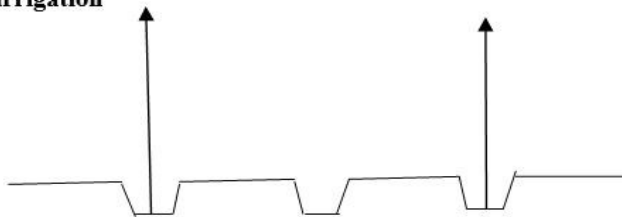


**Land formation sectional view**

Fig. 3a. Land formation of raised bed and furrow for Racy Nature Agriculture under rainfed situation.

[The raised bed-furrow land form supplements adequate oxygen diffusion in the root zone, increased moisture and nutrient reserve for plants under water logged as well as dry condition.]

**Sprinkler irrigation with highest uniform spray irrigation**



**Land form of raised bed furrow for Racy Nature Agriculture**

Fig. 3b. Land form of raised bed and furrow and sprinkler irrigation for Racy Nature Agriculture.

[The sprinkler spray application of irrigation water will increase oxygen content; it will supplement the raised bed enhanced storage of nutrients and moisture and sufficiently aerated, occasionally saturated and drain off the excess water to keep always convene aerobic decomposition of organic and cellulose. This will supplement plant nutrient by way of enabling sulphur cycle to function. This situation brings good water and air interaction].

The component details are listed in Table 3 with elaborated and concise description. The contribution of different practices constituting the technology as well as the composite effects, are summarized in Table 3. The individual component practices have capacity to enhance yield in range of 5-15%. The composite effects comes out to be almost bringing the double the present harvested yields.

The values in table are arrived at were based on the research results reported by various successful researches. However, the combined effect is expected to come to the same quantum. There will be scientific skepticism about the results that these combinations will produce. It is well proven that whatever claims are being made here have performed still more than that has been brought out by theoretical implications. Hence, scientists will get convinced in very short time, when research results get disseminated by the internet medium, being main way of literature survey.

In the racy nature technology several breakthroughs are brought in. These are application of NADEP composting to create sulphate, raised bed and furrow, precision transplanting, ultimate green irrigation practice, weeding, inter-culture, harvesting, post harvesting, drying and processing infrastructure etc. which will bring world agriculture to a new plateau. Further, this is a quantum mechanics based agricultural technology which has a strict module suitable for all crops, cropping patterns both for rainfed and irrigated agriculture. The component practice and module should not be altered as it is based on innovative application of scientific facts and several innovations have been brought in this nature agriculture

since 2013. The module is quantum mechanics based and is fixed and no need of deviation. The route is fixed and it only needs optimization, which can be brought in by customization under local situation.

This nature agriculture enables pin down the shortfall and apply boosting correction to make such shortfall. This true scientific development of productive agriculture for any crop and ecosystem one can think of. Thus this technology fulfils long term experiment to make it statistical sufficiency. The sun technology overtakes that scientific wisdom prevailed in early days and presents fixed module and having sound scientific based make up of shortfalls. The science comes up with simple innovative solutions which have not existed in the scene. Researches in racy nature agriculture have produced several generation based advancement in the practices for rice, wheat, pulse, weed management, super micro irrigation and resources conservation and production to bring sufficiency of food for the present and posterity. The production technology will provide work opportunity and scope for huge population to enable prosperity of any nation of the world.

• *Yearly yield Enhancement and Water conservation*

The data presented in **Table 4** substantiate that paddy wheat is the most remunerative and stable cropping pattern in Punjab. Paddy is cultivated during rainy season when water availability is more; though distribution pattern is unpredictable. The wheat crop is grown during winter when water demand is low due to low evaporative demands. But, even under these situations wide spread withdrawal of ground water had caused alarming concern of fall in ground water depth. Different methods of paddy cultivation are being resorted to with a view to reducing water demand for paddy. At most alternate wetting and drawing practice of paddy irrigation have been practiced. The first author developed an ultimate green irrigation practice [24] which fulfills all necessary requirement of green chemistry and saves water. The sprinkler irrigation is applied for uniform saturation of soil profile and during high water demand at crop stage of tillering and ear head emerging stage by over flooding the furrows. Thus, high yield can be harvested with low water consumption.

The water need for irrigation can be reduced by changing wheat crop with mustard or gram. By changing crop of rainy season viz maize followed by gram will produce REY at par with that of paddy – wheat (**Table 4**). There will be tremendous reduction in water demand for agriculture. This research has demonstrated ways and simple means to acquire it. The raised bed and furrow land form will equip the soil with more moisture, nutrient and perform green chemistry for longer duration than a flat bed. Further, furrow over irrigation at time of high water demand will become ultimate irrigation that will conserve water and produce high harvest index. Utility of raised bed and furrow, NADEPED composting, application of Zn and S, and ultimate irrigation which are devised and substantiated in the present study fortify the claim of achieving high yield and conserving water and nutrients by application of innovative technology of racy nature agriculture. The residual effect of Zn applied for wheat will bring high yield even without application of Zn for wetland paddy [33].

Table 4. Yearly cropping sequences wise paddy equivalent yields (REYs) for Punjab, India [12]

Treatments	Crops and yields, q/ha		Paddy equiv yieldq/ha
	Paddy	Wheat	
Control	45	30	
PEY	45	22.5	67.5
Aerobic and nutrient managed RACY nature	114	76	
PEY	114	57	171
Ratio	2.53:1	2.53:1	2.5:1

### 3.4 Subsidy and Man Power Development

Excessive dose and inappropriate application method of nitrogenous fertilizer will lead to N loss that will produce nitrate load in runoff stored in the water bodies and well waters. Excessive nitrogen and Phosphorus losses cause eutrophication in the water bodies by bringing profuse growth of water hyacinth etc which cause fish kills as the oxygen dissolved in water get utilized by the floating plants. The eutrophication also leads to the death of water bodies leading to no inland storage and lack of ground water recharge culminating in the development of severe effects of droughts.

There occurs misbalance in the nitrogen cycles. The North Europe is infested by heavy load of nitrogen and at the same time the Gulf suffers lack of nitrogen in soil due to excessive withdrawals. Both the situations are harmful to the people and the environment [17]. Thus, in order to avoid this type of misbalance in nitrogen cycle (Fig 1), there should be careful application in agriculture. This study has substantiated these facts for paddy nutrient application. There have always been debates on reduction of subsidy of nitrogen fertilizer viz urea, which is the main form of available nitrogen formation brand. Scientifically, it demands that the reduction on subsidy should be added on to subsidizing other input such as Zn, S and agricultural machineries including sprinkler setups. These subsidies will enhance yield and harvest index [26]. ---- [30].

The development of new technology of racy nature agriculture and the component practices of it need familiarization. Short duration training to the policy makers as brain storming session, agriculture executives and implementers at various levels including farmers need to be organized. The state Governments should consider providing necessary fund for organizing such informative and orientation building training programmes in agriculture. Thus, the transformation in agriculture from low yielding and risk prone can be made as high yielding and assured.

### 3.5 Linkage between Various Aspects of Technology for Paddy Cultivation, Environment and Blame on Reduction of Area under Paddy Cultivation

This research aimed at creating technology for enhancing yield of paddy, which is staple food for almost 50% of global populations, mostly living in South East Asia including India, for which western countries had been levying blame of causing release of methane, thus putting pressure to reduce area under paddy cultivation. Thus, domain of the researches has become broad. Largely,

researches had focused one or two aspects and not attempted the problems as enumerated in totality. This research has brought innovative development for macro and micro nutrients and their management, which had lacked innovative development in cultivation of paddy, particularly nutrient management. It emphasized nutrient management for sustainable use of macro and micronutrients. It presented a natural affective method of Zinc and Sulphur management for enhancing N, P, K and Green Water use efficiency. It demonstrates highly suitable cropping pattern of paddy wheat and reduced doses of Zn and S that will reduce cost of cultivation and enhancement in resource use efficiency. The innovative technology was able to produce Paddy equivalent yield to the effect of Innovated: existing practice:: 2.5: 1. Further, it uses naturally available indigenous resource for supplementing Zn and S. The technology has discretized operations and effects can be isolated to identify cause of any shortfall make up shortfall in the yield level. The system eliminates methane and any nitrous oxide and provokes aerobic cultivation of paddy. This will eliminate carbon foot print, reduce emission of GHG methane and N<sub>2</sub>O, as well as it gives diversified commodity for better quality of food. Studies at European Commission Joint Research Centre report [26] indicated the likely saving in water requirement due to consumption of quality foods possible due to non dispensable use of water in raising fish and shrimps. Thus, this research has fulfilled all major aspects of paddy cultivation without any restriction in extension of area under paddy that will create sustainable food supply for large population. The inappropriate rice production technology produce methane and nitrous oxide, which are environment degrading emissions [30].

## IV. DISCUSSION

The studies have brought several innovations which support the racy nature agriculture to become the most innovative technology for agriculture and which can be additionally applied for paddy cultivation. The scientific facts of nutrient application requires cultivations including the paddy cultivation to be aerobic i.e. well drained to have moisture in the range of 80-85% of available moisture for rainy season crops, be paddy and about 75% for winter season crops such as wheat. These moisture supplies can be easily supplemented by ultimate practice of green irrigation for racy nature technology. Thus, under no condition the paddy crop should fail due to occurrence of drought.

For the paddy based cropping pattern where crop gets suffered by late flood damage, a suitable cropping practice will be by innovative application of nitrogen cycle. In the standing crop field and nearing to harvest either lentil/lethyrus or pea can be sown in October, which will germinate by the harvest of paddy [18]. In this field wheat should be directly sown at optimized seed rate that will utilize the nitrogen fixed by either of the pulse crops. It needs optimization of wheat seed rate for sowing of these pulse growing fields. If there is shortage of moisture supply the field should be irrigated by the ultimate green irrigation practice. There will be saving in cost of tillage and use of

fixed nitrogen which is not possible in the zero tillage. Thus, yield of both pulse crops and the wheat will increase by scientific management of nitrogen cycle in flood affected paddy fields.

As depicted in this study, India with large hectare under paddy with different modes of cultivations produce average yield per ha. There are several modes of paddy cultivation, but the nutrient management both macro and micro are still not precisely carried out that results in low efficiency of resources of land, water, nutrient and labour input in cultivation of paddy. The new dangerous scenario of global warming and climate change will make the situation from bad to worst. There is vast scope of improving the yield of paddy, as elucidated in the racy nature agriculture. The innovative technology of racy nature agriculture is an excellent and fool proof, always true to hold good and an answer to all these problems. The nature agriculture is free from all wildernesses in agriculture as it involves quantum mechanics in agriculture [17]. There is no alteration, rather, same technology is to be applied for all crops be it rainfed or irrigated agriculture. Many innovative developments have been brought in it and their application will equip agriculture with new technology. There will be some pros and cons ideologies in the scientific world, but detailed study of the technology [15], [17]] will make all doubts clear.

The study had made innovative application of scientific facts and devised innovative practice for cultivation of paddy. The study has taken support of published researches to substantiate and validate the technology and role of zinc and S in paddy, their water and environmental interactions, which bring good and bad effects and cause GHG emissions. Thus, first role had been established and following that most suitable paddy cultivation practice devised and contrasted with the ongoing ones.

Towards the nutrient management the nitrogen cycle, sulphur cycle and zinc cycle play important role. The inadequacy of application of these scientific facts kept a black box situation to exist. The scientific facts lead to the situation that experimental studies on nutrients are largely confined to generation 1G, wherein the first stage of identifying the alternative of efficient measure are explored. These inferences could be drawn even without conducting field experiments. The next stage of optimization of doses presented in **Table 3** should form the agenda for the scientific research that will save resources devoted to paddy cultivation, make these efficiently utilized and production sustainable. This study has brought out, based on the scientific facts, the correct practice of nutrient management in paddy. Thus, the practice is fixed and it should not be altered in order to harness benefit of input use in paddy cultivation. In the ongoing practices there might be several situations which will be developing in the paddy field that will reduce yield levels. In such situations farmers become helpless and bear the loss for their input in paddy production. The new technology viz racy nature agriculture will be saviour for farmers from such grim situations world over.

The racy nature agriculture is a technology which enables bringing crop diversification. Many types of crops viz

maize on the raised bed and paddy in the furrows and their banks can be cultivated that will permit inter cropping and enhancement in the yield and Land Equivalent Ratio (LER) [32] [33]. However, as a second generation 2G optimization researches need to be carried out for this cultivation practice. The aerobic/well drained condition will enable development of green chemistry of Zn and Sulphur that will result in higher harvest index than otherwise when applied in submerged land condition. If there can be a leguminous crop, it will supplement nitrogen; one fourth dose which is required as organic dose specified in the earlier part of the study. When NADEP compost is applied it will supplement Zn and S in the field that will increase and make sustainable productivity of paddy. Farmers of Uttar Pradesh have had experience of NADEP compost during the programme of agriculture support project funded by the World Bank undertaken later part of decade of 2000. During this project although the benefits from the NADEP were realized by the farmers, but the knowledge about the green chemistry was not endowed in it. Hence, the continuity could not be created on the use of NADEP compost. Farmers now apply zinc with urea as a split dose after transplanting, which is not likely to be beneficial.

Further, under the submerged condition there will be formation of zinc sulphide and hydrogen sulphide which will work as poison to the paddy crop. There may occur several kind of adverse effect on the crop. Disease of crop drying which is known as *Jhulsa* may be the one of the adverse effects of hydrogen sulphide. It needs some experimental verification.

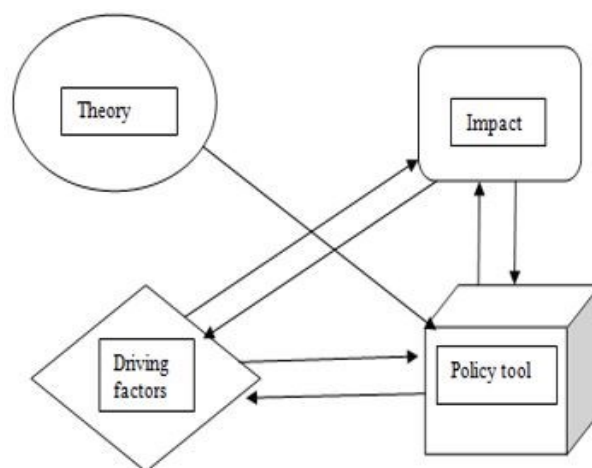


Fig. 4. Link network of Theory, Impact, Driving factors and policy tools.

Write Fig 3 inplace of Fig 4

This study has set nutrient management in paddy production based on theory. It has elucidated the wilderness in the rice production technology in general and nutrient management in particular. The earlier style of nutrient management has been inefficient and detrimental. Therefore, as a principle (**Fig 3**) broader approach should be based on theory and local corrections should be based on customization by the local researches. This strategy and approach of nutrient management in paddy cultivation will

bring several improvement viz yield, sustainability and resources conservation.

## V. CONCLUSION

The ongoing wrong nutrient management practices were elucidated and substantiated in the prevalent methods of paddy cultivation. Although there are some innovations coming up in seedling raising, transplanting and adoption by the farmers, the nutrient management has been in unscientific manner that leads to getting no full benefit of inputs. The innovative application of scientific facts and experimental substantiations lead to conclusion that urea is the best mode of N supplementation for paddy to reduce the leaching losses. As a principle, one fourth of total N requirement of paddy crop should be organic based by application of NADEP compost. Zinc should be applied as basal dose at transplanting. The sulphur should be applied with the final dose of N application along with top dressing at ear head emergence/grain filling. Nitrogen, Zn and S use efficiency can be enhanced when aerobic cultivation of paddy is carried out. The racy nature agriculture is an innovative technology for paddy cultivation to acquire yield at par or even more than those harvested in many high yield harvesting countries. In the wheat- paddy cultivation the residual content of Zn application to wheat and application of NADEP compost to paddy will supplement zinc requirement in submerged field paddy cultivation. The breakthrough of irrigation and cropping pattern created in the racy nature agriculture will enable assured paddy harvest against drought and flood ravages in agriculture.

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## REFERENCES

- [1] Debora Bossio H and Geheb Kim, Conserving land protecting water: an introduction. In Bossio Deborah and Geheb Kim.2008. *Conserving Land Protecting Water Comprehensive Assessment in Agriculture*. Series CABI, in association with CGIAR Challenge Program on Water and Foods, International Water Management Institute Sri Lanka, (2008). pp XI-XVIII.
- [2] Crolina Thomas, and Tony Evans, Poverty, Development and Hunger, in Bayliss, John, Smith Steve and Oven Patrics, (Editors). 2011. *The Globalisation of World Politics: An introduction to world relations*, Fifth Edition, Oxford University Press, (2011). 471.
- [3] Wilfried Ehlers, and Michael, Goss, *Water dynamics in plant production*. CABI Publication, Walling Ford, U.K. 2003.
- [4] M.S Aulakh, Reinder Wassman, Heinz. Emission from rice fields, Quantification, Role of management, and Mitigation Option. *Advances in Agronomy* Press. (2000).70:60-267.
- [5] Inderpal Kau, Seema. Agricultural degradation and human health – Inter district analysis. *J Adv Research in Alternate Energy, Environment and Ecology*.2015, 2(1-2):45-55.
- [6] R.C. Yadav Geology and Geographical Implications on Food Related Health Hazards and their Remedial Measures. *8<sup>th</sup> WSEA conference on geology and geography*. Salerno University, Italy, June, 28-30, 2013
- [7] Wandy Horobin, (Ed.) *Protein, How it works, Science and Technology*. Vol 13 Scavandish Corporation, USA. (2003). pp 1864-1866 (2): 141-146.
- [8] A.E. Guftafson,.)Hand Book of Fertilisers, *their sources, make, effect and use*. Third edition, Agro Bios, Jodhpur, India, (1939/2010), pp 15.
- [9] Hammer Mark, J., Hammer Mark, Jr, *Water and Waste Water Technology*. Printice Hall of India. New Delhi 110001 (2005).
- [10] AK, De Environmental Chemistry. (7<sup>th</sup> Edition). New Age International Publications. New Delhi: (2010):7- 13.
- [11] M.Davis and DA. Cornwell. *Introduction to Environmental Engineering*. McGra Hill Book series. Inc. (1997): 33-36.
- [12] R.C. Yadav,., Innovative application of scientific facts for nutrient recovery from waste water streams for sustainable agriculture and protection of environment. *Hydrology: Current Research*. USA (2012). (5): 1000142.
- [13] KM Cimrin,., V Yogay,., F. Senmiz. Effect of different sulphur and pyrite levels on yield, components and nutrient uptake of lentil (*Lens culinaris*) *Indian J Agr. Sci.* (200875 (1):543-548.
- [14] Rashi Seth,., R, Chandra, Manvendra Kumar, AK. Tyagi. Utilization of composted sugar industry waste (Press mud) to improve property of sodic soil for rice cultivation. *J Envi Sci and Engineering*. (2005). 47(3) 212-217.
- [15] R.C. Yadav Racy nature agriculture versus other like technologies: A technologies contrast. *American Eurasian J Agric and Environment Sci.*13(10).1412-1439. Doi10.5829/idosi aejaes. (2013). 13.10.112531
- [16] R.C. Yadav, Innovative applications for scientific facts for zero methane emission and enhancing productivity of paddy fields for sustainable global food security: A conceptual model. *Frontiers of Environmental Sciences and Engineering*, USA December. (2013b).
- [17] R.C. Yadav, Innovative application of scientific facts for arresting GHG-N<sub>2</sub>O and improvising lucrative ventures with enhanced land, water and nutrient use efficiency, *Journal of Energy and Environment*. (2014a).
- [18] RC Yadav Innovative application of scientific facts and irrotational mechanics to develop green chemistry to endow racy nature sustainable agriculture. Intern I. Green Chemistry. Sci Res. Pub. (2016).
- [19] K Kannan,., DK, Kundu,., R Singh,., AK Thakur,., And SK. (Chaudhari, productivity and water use efficiency of aerobic rice under different moisture in Eastern Inda. *Indian j Soil Cons*. 2015) 44920:170-174.
- [20] R ahman Khan, AR, Gurmani MS, Khan AH. Gurmani Effect of zinc application on rice yield under wheat rice system. *Quarterly Sci Vision*. Pakistan (2007).
- [21] M. Ayuso, , T Harnendez, Garcia, C, JA. Pascual Stimulation of barley growth and nutrient absorption by humic substances originating from various organic materials. *Bioresources technology*. (1996). 57:251-257.
- [22] A., Rahman, M Yasin, Akram and ZI Awon.. Response of rice to zinc application and different N sources in calcareous soil. *Quarterly Sci Vision* Pakistan. (2002): 891):103.
- [23] R.C. Yadav, Innovative application of scientific facts for production of designer quality rice. *Intern J. of Advancement in Research and Technology*. 3(10)150-189. Photon, (2014b) 128 : 486-520.
- [24] R.C. Yadav, The ultimate green irrigation practice by innovative application of scientific facts. *World J Agronomy, Food Sci. and Technology* (2015b).2(1):1-30.
- [25] R.C. Yadav, Development of Universal ultimate green Chemistry and eco agriculture for sustainable productivity. In V.P. Singh etal. Ed.). *Water Resources Management Water Science. And Technology* Library .78.http://doi.org. (2018) /10.1007/978-981.10.5711-3.4
- [26] Times Trend TOI. How eating healthy ccan save planet-Change in diet can cut an individuals wtwer foot print. *Times of India*. New Delhi, Noida, Ghaziabad, 12 Sept 2018 pp25.
- [27] R.C. Yadav, L.M. Yadav, S.C. Yadav. Green chemistry prodent plant physiological manoeuvre for enhancing crop productivity and fostering oxygen buildup in environment. *Sci Fed Journal Plant Physiolo*. (2018) 1:1:16 pages.
- [28] J.G. Lauren,., J.M., Husain, M.I., Shah, G ASM Talukder, and CA Heismer,., P Duxburemanent. Raised bed cultivation improves improves nitrogen and water use in rice.-wheat system in South Asia.. In *18<sup>th</sup> World Congress of Soil Science*. Philedelphia, Pensilvania, USA.9-15, July, 2006.
- [29] K.D Sayer, Raised bed cultivation. *Encyclopedia. Soil Sci*: 2000:

- 1-4.
- [30] Times Trend TOI. Why rice farming is bad for climate. *Times of India*. New Delhi, Noida, Ghaziabad, 12 Sept 2018 pp25.
- [31] Tan Mustafa, H Ibrahim and Erkovan Using companion crop of barley to improve white clover production in highland of Turkey New Zealand J Agri Research (2004). 47:20-21
- [32] R.C Yadav. Cropping practice for makeup of shortfall in pulse production and reduction of GHG nitrous oxide. Archives in Chemical Research. (2017). 2(5):10
- [33] R.P. Yadav, R.K Aggarwal, P Singh, S.L Arya, AK. Tiwari, AK. Bhattacharya, R.Prasad and M.K Yadav, Effect of supplemental irrigation and nutrient management on wheat (triticum aestivum) productivity in rainfed Shivalik ecosystem. Intern j. tropical Agriculture 2006. 24(1, 2): 257-267.

## AUTHORS PROFILE



### Dr. R.C. Yadav

Ram Charan Yadav was born in Tehsil Gyanpur in the then district Varanasi, now Sant Ravidas Nagar (Bhadohi), Uttar Pradesh on 15 Sept, 1944. He completed primary Secondary and Intermediate education in Schools and Colleges available in the area. He completed B.Sc. Agri Engg and Tech from the then UPAU, Pantnagar in 1968 and M. Tech in Soil and Water Conservation Engineering from IIT, *Kharagpur* in 1970. After working for 22 year he again satrted Ph.D. studies and completed his Ph.D. in Water Resources, Civil Engg from IIT, *Mumbai* in July1997. He joined fist service as Jr. Research Engineer at Experimental Research Station, University of Udaipur in 1971, then as Assistant Professor in College of Engg. in the same University and then joined at Central Arid Zone Research Institute Jodhpur in May 1972. He worked as Engineer de Etta in Ministry of Hydraulics, Land Improvement and Environment, Government of Algeria on Foreign Assignment for two years from Nov 1977, then Joined as Lecturer in Ahmadu Bello University, Kaduna State, Northm Nigeria. He again returned to ICAR in 1985 and continued as Senior scientist at CSWCRTI, Research Centre, Agra. He became Principal Scientist in 1998 and then as Head of the Research Centre Agra from Nov 2001-Sept 2006. He worked for short term assignments in ASRB post retirement he took assignments as Professor in UP Tech University colleges in 2008 and Foreign Universities in Eritrea in May 2009-Sept 2011 and worked in Ehiopian from Nov 2011 till July 2014. Dr Yadav brought several refinements in use of conservation structure and watershed management and associated technologies during his service in ICAR and he pursued his researches and created several innovative researches viz smart, alive and enthusiastic (RACY) nature agriculture. He created innovations on nitrogen cycle management and developed innovative practice of nutrient, weed management under nomenclature of zero weeding agriculture, Super-micro irrigation as superior replacement of drip irrigation and biotechnology of crop stand establishment for crop production. He received UNESO grant for his B. Tech student Project In Ahamadu Bello University in Nigeria, ICAR *Pandit Jawahar Lal Nehru* Award in 1999for Outstanding PhD Thesis work at IIT, Bombay. He received Engineering Research Fund Award for social welfare research and Thomas Edition Award 2012. Professor *Yadav* was awarded World Academic Championship in Chemical Research 2017, World Academic Championship in Biological Sciences in 2018 and again World Academic Championship in Agricultural Sciences, 2018 for his research articles published in renowned international journal of reputations. Professor Yadav has developed Agriculture System for Vision Agriculture 2050, which will become new stake for developing World Food sustainable Sufficiency.



### Professor V.W. Ambekar

Er. Vasant Wasudeo Ambekar, was born at Tehsil Pandharkawada of Distt Yeotmal in Maharashtra on 6<sup>th</sup> of May 1938. He had his earlier education up to High school level in his native town. There after he did his graduation as B.Sc (Agriculture) from Nagpur University in the year 1958. This was followed by obtaining B.Sc (Agriculture Engineering) degree from Allahabad University in the year 1961. He joined the Department of Agriculture, Uttar Pradesh as Technical Assistant (Engg.) in the year 1961. He completed his 6 months training course in "Soil & Water Conservation" at "Soil Conservation Research, Demonstration & Training Centre Dehradun. Subsequently he worked on

various posts as Soil Conservation Officer, Dy. Director Soil Conservation, Joint Director Agriculture (Engg), Additional Director of Agriculture (Soil Conservation) & ultimately headed the Department of Agriculture, UP as Director Agriculture from 1990 to 1995. While working in Department of Agriculture, he handled "Soil & Water Conservation, Watershed Development Projects" related to Ravine Land Reclamation as well as Reclamation of Salt affected Soils. He also worked as Director of State Institute of Agriculture Management at Rahmankheda, Lucknow in the year 1995 – 96, from where he retired on 31<sup>st</sup> May 1996. After retirement Professor Ambekar worked as an advisor with two World Bank aided projects i.e. "Diversified Agriculture Projects of UP" & Sodic Land Reclamation Project during year 1996 to 2002. He also worked as National Level Monitor with Ministry of Rural Development, Govt. of India for monitoring of Ministry's various schemes and projects. Professor Ambekar was also associated with Agriculture Finance Corporation as "Consultant" for Monitoring and evaluation of various projects of "Soil & Water Conservation" and "Watershed Management". Also taken up preparation of prospective plans for various districts of UP for the implementation of "Mahatma Gandhi National Rural Employment Guarantee Program (MANREGA), during the course of his job, Professor Ambekar attended number of Workshops and Seminars and presented papers on various aspects related to Agriculture, Soil & Water Conservation and Watershed Management.