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Cropping Practice and Makeup Shortfall of Pulse Production with Reduced Emission of Green House Gas-Nitrous Oxide

Yadav RC*

Water and Environment Interaction Specialist, Former Head, ICAR Research Centre Agra, 282006, Uttar Pradesh, India

Corresponding author: Yadav RC

ramcyadav@rediffmail.com

Water and Environment Interaction Specialist, Former Head, ICAR Research Centre Agra, 282006, Uttar Pradesh, India.

Tel: +919650995704

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Abstract

Intercropping is a known and adopted practice in agriculture world over. However, there is no specific set rule for operating it and hence so are the experimental results. The objective of this study was to innovate a set principle of inter cropping for universal applications in agriculture. The study presents yield data from earlier researches and analyses to innovate the principle. It applies the principle of nitrogen cycle, sulphur cycle, environmental chemistry, alellopathy, spatial and temporal considerations, physics and chemistry, microbiology, environmental science and devised principle of the inter cropping. The principle is that in inter cropping a legume crop is must as an associate crop. The row ratio of main crop to the associating crop should be such that it allows to obtain maximum production of any main crop; thus, it should invariably be 1:1 for close growing main crop and 1:2 for wide spacing main crops. Intercropping that can be with oil seed and cereal mix crops are based on compatibility of light, nutrient, soil moisture, insect pest reduction, weed control and economic return; all of them will also get covered under this set principle. For a case study a green gram equivalent yield of 12 q/ha and above was justifiable for inter cropping. This set principle will apply to all crops and intercropping, on the line of quantum mechanics (a set principle of function) that will help reform world agriculture. The innovative doctrine will enable make further several innovations in agriculture. The shortages in pulse production will get made up by the intensive practice of intercropping practice on new doctrine.

Keywords: Biodiversity; Climate resilient agriculture; Environment; Natural resources management; Nutritional food security; Land degradation

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Introduction

Intercropping is a known and adopted practice in agriculture both rainfed as well as irrigated world over. However, it is based on individuals' will and wisdom to follow it in different ways with their perception and justification viz for fodder crop, Thus, there is no any specific set doctrine and so are the variable benefits from the practice. The recommendations culminate in to variable degree of success of utilization of resources, inputs, efforts and time [1,2].

The practice of mixed cropping is as old as the agriculture, since development of nomadic agriculture to the present day modern agriculture. It involved sowing of mixed crops that enabled closeness of main and the supplementary crops that fixes nitrogen to be utilized by the main crop. Largely utility of leguminous crops has been known from the practical consideration. With the introduction of line sowing that is easily carried out by mechanization, the closeness is reduced in the bands. Thus, the advantage to individual plants of the main crop from the individual associating crop is reduced. The mixed cropping is again getting popular due to resort of broad casting in many situations. The mixed cropping in general lacks any set doctrine. This potential practice demands some innovative doctrine to improve its efficiency and workability. Thus, intercropping will be a feasible and affordable innovative savior of ameliorating problems associated with agriculture, environment and ecosystem [3-10].

Excessive application of chemical nitrogen fertilizers produce nitrate which joins ground water. Insufficient centralized treatment of sewage from the rural areas promotes nitrate concentration in the ground water. Environmental pollution

with a number of organic and non-organic chemical products (nitrates, pesticides, thio-cyanate, phenol etc.) influences in one or another way the relative iodine deficiency or directly suppresses thyroid hormone synthesis. The iodine deficiency translates goitrogenic effect and stimulating the manifestation and severity of iodine deficiency disorder (IDD) in regions with endemic iodine deficiency. Nitrate is the most common chemical contaminant in the world's groundwater aquifers harmful to human health. Its intake in humans is via drinking water and food and might affect the thyroid gland function. The nitrate ion (NO_3^-) inhibits iodide (I^-) transport into the thyroid gland because it shares the same transport mechanism. This inhibition could lead to a decrease in thyroid hormone (T4, T3) secretion, followed by an increase in Thyroid-Stimulating Hormone (TSH) and thyroid gland enlargement (goiter). Therefore, it requires regulation of Nitrogenous fertilizer in wet agriculture viz paddy cultivation. In the intercropping the nitrate building and utilization go simultaneously, leave less scope for nitrate loss than with other agricultural practices.

The benefits from the intercropping are enhancement in biological nitrogen fixation, enhancement in yield, enhancement in land equivalent ratio (LER), economic return, increase in commodity quality, reduction in insect and pest damages, climatic stress resilience, reduction in land degradation, increase in the livelihood dependence, reduction in dependence on market for domestic needs etc. Some researchers have attempted to develop model and some on the optimization of combinations. However, these models have not proven their worth in the intercropping. The objective of the present study was to develop innovative universally applicable doctrine for the inter cropping [11-15].

Materials and Methods

Enumeration of relevant scientific facts

In order to make the nutrient supply an endless revolving chain is to be created which is cycle of movement. The 14 important nutrients for plant growths are listed by Gustafson 1939/2010 **(Table 1)**. Among them the nitrogen is the most important one followed by P, K, Ca, Mg and Fe. Other micro elements are Mn, Bo S, Z, Cu, H, O and C. For inducing sustainability there should be mechanism to build up using these mineral nutrients in to suitable compounds of nutrients and revolve irrotationaly. The green chemistry of the nutrient reactions that enable developments of nutrient compound in form that can be absorbed by root hairs are presented by Yadav, et al. (2016). The mechanism of uptake is universal hence there is need to develop/ create condition as close as possible to the natural ideal condition. Studies by Yadav, 2016 presented universal facts which exist everywhere and enable creating several innovations [16,17].

Data base

The study utilizes data generated by the scientific team of researches, which have been accepted to substantiate some facts. Further, these and other relevant experimental studies supported perception of novel theme and substantiation of the hypothesis of this study. The study demonstrates the findings which lead to development of innovative doctrine for the inter cropping. The doctrine, its application and advantages are deliberated and ratified by discussion. Recommendations were formed to derive benefits by applying the innovative doctrine of inter cropping.

Indicators in support of the doctrine

There are several indicators, which include resources buildup, resources utilization and efficiency indicators. These are enhancement of equivalent yield (such as main crop yield equivalent), land equivalent ratio (LER), utilization of spatial and temporal spaces, radiation, soil moisture, nutrients, insect pest control, climatic stress resilience, economic benefits and B:C ratio etc. The new doctrine should take care of these aspects and bring to the highest level.

New quantum mechanics base intercropping modules

The Racy (smart, alive and enthusiastic) nature agriculture was brought on the lines of quantum mechanics so that it follows a fixed path without any wandering. This path will be universal and true for all locations and times. Based on the innovative doctrine of inter cropping, most suitable main crops and nitrogen fixing associating crops, the spacing and bands etc.

Table 1 Elements needed for plant growth.

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

are fixed and presented. The specifications devised on the basis of new doctrine will change with regard to suitable main crop and associating nitrogen fixing associating crop of any location. Hence, the principle remains the same and the crop combinations will change from location to location; may be established by the customization [18-20].

Results and Discussion

As brought out in the experimental details, the results are presented in different subheads.

Selection of crops for inter cropping

The carefully planned and conducted study on inter cropping provided very useful and guiding results. The study showed the criteria for selection of crop combination and further their sowing/planting pattern, which otherwise had been on wild card i.e. on one's own thinking and method. In intercropping the crop should be nitrogen fixing ones such as pulses etc. Thus, it is proven that nitrogen cycle has to function in the cropping system; hence the crop combination should include at least one leguminous crop.

Green gram enhanced yield of pigeon pea another long duration pulse crop and oil seed crop, castor. In contrast, other associating crops viz sesame and pearl millet adversely reduced the yields of main crops. The results on yield, the basic consideration in adopting inter cropping showed both positive i.e. increase as well as negative i.e. decrease effects. It indicated that inclusion of the nitrogen fixing crop in the system always produced positive effect. It further indicated that when both the crops are nitrogen fixing, there occurred increase in yield of long duration legume crop. There occurred utilization of nitrogen fixed by the short duration leguminous crop viz green gram and stored in the soil. This fact clarifies earlier debatable issue whether intercropping of legume in legume will be beneficial? It also clarified that growth habit of crops have some effect on yield. When both the main and the associating crops are of similar growth pattern viz pigeon pea in initial stage and sesame or pearl millet, there is competitions for light, nutrient. Although there might be some amount of nitrogen fixation by the pigeon pea, it was not sufficient to cater high nutrient demand by the crop combination.

The study on inter cropping in the adjacent separate field block revealed yield responses of both the main and that associating crops of castor based intercropping the similar trend. There was visible gain in yield of castor with green gram and negative effect in combination with sesame and the pearl millet. Because the castor is fast growing and robust more than the associating companion crops, it utilized more nitrogen fixed by the green gram crop. When there was no nitrogen fixation by the sesame an oil seed and cereal crop pearl millet, both the crops suffered set back of competitions. The adverse effect of the competition was seen in castor more than that in sesame and pearl millet. Thus, both the blocks of experiments on inter cropping revealed consistent and clear evidence of right type of crop combination for inter cropping. It revealed some ways to increase the volume of production of desired commodity by correct and possible way of inter cropping. It revealed that randomly selected crop combinations do not bring expected level of gains in yield of crops. It further established that crop selection should include at least one crop that enables functioning of the nitrogen cycle throughout the growth of the crop of desired commodity. This is one important aspect coming up in the doctrine in perspective [21-23].

Sowing/planting pattern

After correct identification of the crops for inter cropping next aspect is the location of crop rows of the main and numbers of accompanying crops. As brought out earlier creating nitrogen fixing reserve in the close vicinity of the main crop is the requirement, which had been accomplished in the farmers' practice of broad casting. In the line sowing, the inter crops are to be sown in bands of the crop rows. In our study the pigeon pea and castors were wide row spacing main crops (45 cm-90 cm). The data in **Table 2** revealed that pigeon pea yield increase was substantial even at main crop and inter crop ratio is 1:1, with higher yield of the main crop under inter cropping than sole crop. When the inter crop is doubled, i.e. main crop to inter crop ratio 1:2, the yield of the main crop is reduced and the yield of the inter crop is increased. The main reason behind this situation is the reduction of plant density/ha of main crop and increase of that crop density of the inter crop. Thus, there appeared some scope to alter the crop row ratio to keep either band of 1:1 or 1: 2 are fixed. The slight variation from the optimum can be acquired by increasing density of both the crops viz main crop and associating crop. This is site specific which falls under the purview of customization. Thus, the main crop and inter crop ratio should be 1:1 for close growing crop and 1:2 for wide spacing main crop. The main crop can be any one of the three i.e. either cereal, oilseed or pulse crop, depending on where interest lies in producing highest volume of the commodity desired. The inter crop has to be nitrogen fixing crop. Thus, both the aspects of selection of the crops and the planting patterns are fixed as a doctrine for all inter cropping for harnessing benefits from the spatial and temporal variations.

There may be situation that a close growing crop rows of three and more are to be sown, but under this situation the name of the practice will be strip cropping instead of inter cropping. The objective behind the strip cropping is to make it function as vegetative barrier for soil and water conservation [24,25].

Green chemistry of inter cropping

The selection of crops is the accomplishment of the best crop combination in consideration of biology and physics consideration. The nitrogen fixation involves charter of green chemistry of nitrogen fixation, conversion in ammonium and nitrate form, which are easily absorbed by the root hairs. The entire aspect of the green chemistry of nitrogen cycle was extensively developed by the author in other studies. The management of nitrogen involves building and simultaneous utilization of nitrogen reserve in soil so as to keep rate of release of nitrous oxide (N_2O) lowest in the process of nitrification and denitrification. Thus, inter cropping is similar to creating a miniature, but extensive sources for the nitrogen building and simultaneous utilization of the stored nitrogen. The system works as a balanced miniature ecosystem.

Table 2 Corp compositions for yield, LER, economic return for pulses, oil seeds and cereal crops.

Cropping system	Yields of crops , kg/ha		Pigeon pea gain equiv, kg/ha	Land equivalent ratio (LER)	Benefit /Cost ratio, B/C
	Main	Associated			
Pigeon pea based intercropping					
Sole pigeon pea	777		777	1.0	1.94
Pigeon pea + green gram 1:1	845	218	1000	1.54	2.26
Pigeon pea + green gram 1:2	795	331	1034	1.61	2.33
Pigeon pea +sesame	676	81	773	1.35	1.79
Pigeon pea + pearl millet	566	614	639	1.16	1.49
Castor based inter cropping					
Sole castor	1945	-	946	1.0	1.57
Castor + green gram 1:1	2130	161	1195	1.46	1.80
Castor+ green gram 1:2	2093	292	1307	1.62	1.85
Castor+sesame	1873	66	1103	1.32	1.50
Castor +pearl millet	1814	490	945	1.16	1.39

Thus, inter cropping is an ideal method for control of the Green House Gas (GHG) nitrous oxide, which largely emanates from soil and agriculture. The nitrous oxide has now become prominent GHG emission, more than carbon dioxide (CO_2) and methane (CH_4) for which it was declared as a challenging task to develop simple and feasible measure. Thus, this study created a simple means of reducing emission of the GHG nitrous oxide from soil and agriculture.

In addition to the green chemistry of nitrogen, chemistry of sulphur cycle is another new innovation in agriculture revealed and developed by other studies since deficiency of sulphur is getting focussed, but no simple measure is coming up. Except application of elemental sulphur and pyrite, there has been no simple manageable method to build sulphur. The sulphur cycle follows two paths for its development, which have some implication on the management of sulphur in agriculture. The crop residues, especially cellulose etc. are decomposed by aerobic digestion under the aerobic composting (NADEP composting). Sulphur cycle needs aerobic condition to produce sulphate, which is absorbed by the plants. There has been, in general, deficiency of micronutrient sulphur. Farmers' are encouraged to apply a dose of 10-16 kg S in the crops which grows under aerobic condition. The residual of this sulphur dose will be sufficient for the following crop, hence application of sulphur should not be recommended for paddy crop with submerged water. In this situation when the sulphur cycle is managed, there will be buildup of sulphate in the practice. Hence, the S deficiency will get overcome by the inter cropping.

The efficacy of aerobically decomposed compost is cycle working in the intercropping is substantiated by referring data from study in the following (**Table 3).**

The aerobically decomposed (NADEP) composting produced @5 tonnes/ha gives yield at par with that of T4 (vermin composting). The preparation of vermin compost is difficult as it is totally based on voluminous supply of cow dung, which is becoming scarce. Further, birds eat away the earth worms that requires intensive care. The NADEP compost requires less amount of cow dung and utilizes trash, residues and weeds etc. The NADEP composting creates sulphate and the vermin composting creates enzymes, the sulphate is more important nutrient for crops. The research had not notice this aspect of additional quality of NADEP composting i.e. content os sulphur; which has been, in general, lack of sulphur cycle in agriculture but, the effect is harnessed. NADEP also contains P and K more than FYM or the vermin composting. Its preparation is simple, inexpensive and less care sensitive than the vermin composting. The enhancement in yield was close to that from the vermin composting. The B: C ratio is highest with the NADEP. Hence, NADEP compost should be applied to the crop for the supplementation of S [26].

Chemistry in production systems

The green chemistry is ideal requirement for enhancement in yield and protection o environment. The aspects are;

Photosynthesis- green chemistry

$$CO_2 + H_2O \xrightarrow{hv} (CH_2O) + O_2 + \text{Energy} \quad (1)$$

Nitrogen fixation

$$3(CH_2O) + 2N_2 + 3H_2O + 4H \rightarrow 3CO_2 + 4NH_4 \quad (2)$$

$$NH_4 + H_2O \rightarrow NH_3 + H_2O + H \quad (3)$$

Vadose zone leachates in the form of elevated ammonium concentrations occurs that often exceed the maximum admissible concentration for water intended for potable use. In addition, nitrate concentrations in the saturated zone of the sedimentary aquifer system exceed the respective threshold in several cases.

$$2O_2 + NH_4\ NO3^- + 2H + H_2O \rightarrow NO3- + 2H + H2O \quad (4)$$

From the eqn. 1 and eqn. 2, it is clear that in photo synthesis the CO_2 is used to produce carbohydrate and carbohydrate is utilized in nitrogen fixation that produces CO_2 and ammonium. The water is most important ingredient in convening the cycle of both the carbohydrate by photosynthesis and the nitrogen fixation. In the presence of solar radiation and green cover, the

Table 3 Yield of green gram and mustard in agro forestry plantation of aonla.

Year	Crops	Yield under treatments, kg/ha				Cd (P=0.05)
		T1-control	T2-RDF+FYM	T3 –RDF+NADEP	T4-RDF+Vermi compost	
2005-06	Green gram	729	825	1014	935	98
	Mustard	529	659	692	721	84
2006-07	Green gram	291	385	461	492	62
	Mustard	417	536	587	608	42
2007-08	Green gram	126	218	238	254	30
	Mustard	382	495	524	551	38
2008-09	Green gram	145	185	195	208	21
	Mustard	110	200	218	283	44
2009-10	Green gram	175	261	285	305	35
	Mustard	280	385	430	460	56

cycle revolves with speed and for longer duration than in other geographical locations with low intensity and lower duration of bright sunshine. These facts of green chemistry imply that in irrigated condition with adequate moisture supply, the inter cropping will be still better practice than a sole cropping. Under aerobic condition decomposition of carbon will produce carbon dioxide instead of CH_4. The CO_2 has warming factor of 1 and against this CH_4 23. That means, it will reduce global warming, which is a gray chemistry instead of black chemistry. It will fulfill the challenge of development of simple and practical measure to reduce eradication of GHG N_2O.

There is an immediate need for integrated water resources management in the region with emphasis on restoring the chemical quality of affected water bodies. Hence, in agricultural regions the road to socioeconomic stability inevitably goes through environmental protection. The water sources located adjacent to river, canal or annual water courses, are surrounded by areas dominantly agricultural and anthropogenic influence.

The excessive ammonium concentration extracts oxygen that reduces content of O_2 in atmosphere that causes health hazard. The ammonium gets quickly converted in to nitrate, which is very dissolvable in water. Thus, it involves different aerobic reactions. These bacteria are nitrifying and nitrosifying functioning in nitrogen cycle. Resulting good and bad products from the water and environmental interactions aerobic condition for inter cropping are listed in another study. However, Sisbania species survives, grows and fixes nitrogen under dry and wet condition. This fact may be harnessed for carrying out intercropping in wet bed condition such as for paddy [27-30].

Other conditions that favor adoption of inter cropping

In addition to the management of atmospheric nitrogen, there are several considerations viz, better utilization of solar radiation, spatial and temporal soil moisture in the root zone and the space, synergic effects, weed control, insect and pest management, alellopathic and relay cropping and economic gains, etc., which favour for application of inter cropping. When the aforesaid doctrine is followed, the advantages of the other considerations will also get enhanced. Hence, the doctrine envisioned in the present study will cover all the aspects.

Essential requirement of inter cropping

N, P, K, Mg, Fe, S, Zn, C essential elements require O for maintaining their reactions by bacteria. Among them the most prominent species of bacteria are for nitrogen fixing and reduction of emission of N_2O is. *Bradyrhizobium japanicum*. Bacterial strains obtained from cow pea legume exhibited great variability in the efficiency of biological nitrogen fixation and phosphate solubilization especially by *Acinetobacter Sp), Paenibacillus kribbensis, Paenibacillus sp, and Rhizobiales bacterium*. Next is phosphorus solubilising bacteria, and sulphate producing sulphur bacteria. The production of organic acid is related to phosphate solubilization of $CaHPO_4$ and $FePO_4$ for some strains and concentration of acid influences this process. A similar study conducted by Marra, et al. 2012 on some cowpea varieties supported conclusion on the effect of phosphate solubilisation of $CaHPO_4$ and $FePO_4.2H_2O$. The iron (Fe) also needs oxygen to capture several undesirable elements such as arsenic, (As), fluoride (F) and selenium Se etc., which cause health hazards. Depending on the aerobic or anaerobic condition species dominance brings several good and bad effects.

The auto drainage land formation practice

The auto drainage technology provides well drained quickly changing bed condition, which is a characteristic of smart bed configuration to cope with changing aberrant weather condition. The aerobic condition enables bacteria acquire oxygen for breathing. During the dry condition the larger depth of raised bed contains more moisture than the flat bed, which supports plant growth and enhancement of endurance against drought for the longer condition. Thus, there is maintenance of optimum condition of about 75-80 % for rainy season crops and 70-75% saturation for winter season crops. The auto drainage will function sufficiently with provision of suitable drainage outlet from the field. During the drought condition the sprinklers are run, especially during wind free condition that will enable supplementing the raised beds with sufficient moisture. The intermittent droughts will get easily maneuvered by the ultimate green irrigation. Further, during high water demands, the furrows can be little bit over irrigated so as to enable wetting fronts from both the sides of the raised bed touch at the top of the bed. Thus, it will save water, protect crop from water logging and permit

overcoming intermittent drought condition. This bed form and water application system will insure crop production for both rainy season and winter seasons. Thus, it will be universally applicable auto drainage and hydrologically optimum bed configuration for nature agriculture **(Figure 1 a)**.

The provision of ultimate green irrigation and creating endowment of sulphur and nitrogen cycles were not brought in before. Earlier studies on raised bed and furrow system were relied on their enabling diversification of crops. In the present new endeavor with raised bed and furrow, enforcement of nutrient management cycle, ultimate green irrigation fortify it to become hydrologic ally optimum crop bed. In this practice width, depth of furrow and the width of land is fixed as per width of a general purpose tractor i.e. 1.8 m. Thus, variable for keeping the bed at afore said moisture level of 75-80% for rainy and 70-75% saturation for winter season crop can be modeled. Thus, most of the variables are fixed and only under different set of agro climatic condition number of days for which sprinkler irrigation/ furrow irrigation would be necessary, need research studies as customization **(Figure 1 b)**.

Indices of the inter cropping

Like the yield, the land equivalent ratio (LER), also gets enhanced by crop association of legume in the cropping system. Pigeon pea and castor based intercropping study **(Table 4)** established that in the intercropping system the crop combination to be sustainable, the CV should be between 8 and 18% and minimum equivalent yield of 8 q/ha should be adopted for crop combination for intercropping in pigeon pea. Such combinations for castor based intercropping the castor + green gram either paired or single row should be used. Thus, in the intercropping

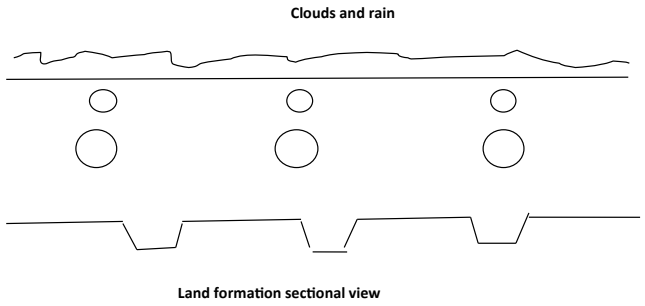

Figure 1a Land formation of raised bed and furrow for Racy Nature Agriculture under rainfed situation.

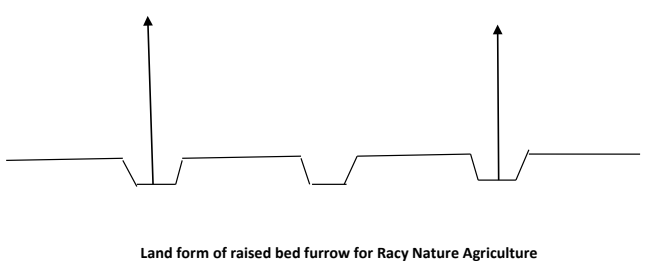

Figure 1b Land form of raised bed and furrow and sprinkler irrigation for Racy Nature Agriculture.

the application of nitrogen cycle leads to show that green gram is an ideal crop for sowing as inter crop. The study has made it clear that in the usual practice the main crop yield can be increased to some extent, but the yield of the inter crop leguminous crop gets invariably reduced. In the other situation of stored nitrogen field crops, yield of both main nitrogen fixing main crop and the accompanying inter crops get increased by inter cropping association. Nevertheless, the quantity of commodities/ha gets reduced. Many intercropping practices have been found economical because of high price of accompanying crop(s). Thus, net gain and benefit: cost ratio (B/C) in the inter cropping are strong index. Other advantages of reduction of weeds, reduction of insect pest damage, utilization of solar radiation, form benefits which get reflected by economic gains.

One most unaccounted benefit of intercropping is residual nutrient status in soil after harvest, which restricts the land degradation due to nutrient deficiency in soil.

Lately, intercropping is established as a simple and feasible way to reduce emission of GHG nitrous oxide (N_2O). It enabled creating inter cropping manifestations for arable land, grassland, forest and horticulture plantations.

New intercropping module by the doctrine and expected enhancement it yields

Based on the established doctrine, crop combinations and planting system modules are devised for universal application of inter cropping for different main crops.

The increase in LER brought by the inter cropping will enhance yield increase, economic return, reduce soil erosion, enhance nutrient in the soil that will eliminate land degradation due to nutrient deficiency and reduce nitrous oxide, now becoming prominent problematic among the GHG. The research need is to replace the green, gram, black gram and gram with suitable and compatible leguminous nitrogen fixing crop for specific region. The planting pattern and row to row spacing's are nearly fixed for all sites. Inter cropping will enable produce cereal, pulse and oilseeds for resources poor farming communities and reduce dependence on market. Earlier strategies produce selective crop as sole crop is defeated by increased LER from the inter cropping [31-33].

Other practices aiding yield response created by new doctrine

Inoculation can be useful for enhancing nitrogen fixation in the leguminous crop which can be utilized by the main crop. Such microbial compositions of inoculants are available in market.

- **Phosphate solubilisation:** the nutrient phosphorus gets fixed in soil becomes unavailable to plants for easy extraction. Studies have established that leguminous crops are able to aid solubilisation in the soil that promotes intake of nutrient and enhancement of crop harvest index.
- **Trichoderma** is also applied for weed control which is added at the time of preparation of NADEP compost, thus cost of application is saved.

New yield plateaus

By careful considerations of production factors yield enhancing factors were drawn. Using the base harvested yield in agriculture, new yield plateaus are drawn **(Table 5).** The yields are high. But, because the factors are drawn from innovative application of scientific facts, the realization of achievability will take some time. When people start practicing the technology, it will become a normal situation get acquainted with results. The random technologies have produced yield to get closure to the technologically resulting yields (**Table 5)**. The intercropping of two rows of potato followed byone row of mustard is adopted practice on account of economic stability, utilsation of solar radiation. However, there no leguminous crop as specified but the new doctrine of inter cropping. Thus, the technology and the yield plateaus cast new hope and reduce global worries on food situation.

Peoples' participation

The production factors apply to all crops of cereals, oilseeds and pulses. The technology module is fixed; it requires only customization by optimization researches. The technology, a strong arm of production, is sufficiently ready to be applied. The next arm is the performing the group jobs in raising production of any commodity at the global scale. It requires human resources development of skill, motivation and creating good environment. The technology application capability requires up gradation of skill and knowledge by training of policy makers, implementing executives and supporting personnel of the production system. Since it is largely a non monetary input technology, there is no heavy budget expenditure for implementation. It requires only seed money for purchase of suitable pulse crop of season and the ground moisture condition. Some budget should be created for training on the technology. The last arm is the convergence of services. These aspects are covered in racy nature agriculture. Creation of infrastructures such as roads, market, banks and allied supports form the convergence of services. These services should be duly acknowledged and displayed. Thus, universal principles should be applied to all crops and commodity produced in agriculture. It is being alerted that by the year 2050 the population growth will be very high. The new technology of intercropping will enhance yield and productions of cereals, oilseeds and pulses to cater the increased demands.

Principle, impact and policy implications

The technology of inter-cropping has been devised by innovative application of scientific facts of the plant science, nitrogen cycle, sulphur cycle, water cycle etc. The technology is universally true for crops and cropping practices for rainfed and irrigated agriculture. The racy nature Sun technology when combined with the inter cropping, it will enhance some equivalent yield viz REY). The local experimentation will help bring customization. The short falls in any component can be made up by incorporating improvement. Thus, this research brings a real scientific development in agriculture on universal principle that displays the right approach of, "think global and act local".

Table 4 New universally applicable cropping practice based on nitrogen cycle management.

S.No	Main crops	Likely total land equivalent ratio (LER)	Adopted LER
1	Paddy	-	1.0
2	Paddy +Black gram 1:1 (On raised bed and furrow	P+BG (1.51)	1.51
3	Paddy + Sisbania 2:1 (25 × 10), Sisbania 25% of normal seed rate	BY (1.51)	1.66
4	Maize(50 × 15)-Paddy(25 × 10), 1:2	Paddy+P (1.54)	1.54
5	Wheat (22.5x7) Regular sowing	-	1
6	Wheat + Lentil,(22.5 × 7)+ (22.5 × 7)	W+Lentil@100 (1.61)	1.61
7	Maize (60 × 20)	-	1
8	Maize (60 × 20)-green gram, 1:2	M+ GG@100 (1.54)	1.54
9	Gram Regular (25 × 15)	-	1
10	Gram(25 × 15) +Wheat (25 × 10), 1:1	Gram and wheat 100% seed rate in rows.	1.75

Table 5 Enhancement in crop yield by inter cropping.

Crops	Base sole crop yield, q/ha	Yield enhancing factor, LER	Yield level after inter cropping, q/ha
Wheat	40	1.61	64
Rice	60	1.61	99
Maize	50	2.54	127
Pearl millet	25	1.60	40
Mustard	18	1.35**	24
Soybean	20	-	-
Gram	24	1.75	42
Pigeon pea	20	1.61	32
Potato	200	1.6	320

*Table devised as per yields achieved in India
** Based on extrapolation
Potato inter cropping, potato: mustard 2::1.

Utility of technology

The technology is based on innovative application of nitrogen and sulphur cycles management. It demonstrates simple means of non monetary input in agriculture to bring to new higher level than with sole cropping. The technology of intercropping will produce multiple benefits viz reduction of drudgery of weeding, yield increases, improvement in soil health, bringing sustainability and bringing resilience in stability due to climate change, improving drainage and conservation of environment on global scenario. The technology transforms the empirical culture to rational science based culture, that will hold good everywhere and for all the times. This technology will be strongest arm of creating new transformation of agriculture. It is applicable in partial compensatory mode of application; it can be promoted by individual participation and collective participation and private scientist partnership (PSP) as ventured in infrastructure projects. Takim, et al. (2012), Tan, et al. (2004) conducted studies on inter cropping with nitrogen fixing crops for enhancing yield of forage in Europe. However, such studies are few and that conducted by Banik, et al., 2006 is exemplary on the aspect of elimination of degradation on account of low nutrient status of soil. There was good scope to take lessons from these studies [34-36].

Discussion

The study was taken up with objective of developing new innovative doctrine of well-known and adopted practice of inter cropping. The requirement of most appropriate crops, both main and associating crops and their bands of location in fields by sowing/planting pattern are prescribed. Necessary condition to make the intercropping possible for all crops, including wet land crop viz paddy, and dry land crop of viz cactus grown in some Gulf countries, can be provided with suitable nitrogen fixing crops such as legumes. The benefit of the nitrogen fixation becomes available for annual and perennial crops such as trees etc. In addition inter cropping provides miniature numbers of plant like sources to get organic nitrogen RNH_4. The benefits culminate in increase in yield, LER, net return **(Table 2)** and the reduction of the GHG nitrous oxide. Thus, the study has created a set doctrine to be applied universally. Thus, its application will produce immense benefits in the world agriculture. Therefore, the study has fulfilled its objective.

The research specifications devised under this new innovative doctrine, although appear to be difficult to apply, but development of multi crop seed drill or the seeding combine will enable very easy application of the innovative agriculture technology of inter cropping. The research institutes have feeling that all machinery requirement for agriculture have been accomplished, but this innovative technology gives scope to give thinking on the usability of existing machineries, be it for tillage or for seeding/ planting. It will require new development of band of machineries for green tillage, multi crop seed drills or seeding/ transplanting combine for green irrigation and operation, and crop functional agriculture.

The green chemistry (eqn.1) utilizes CO_2 and H_2O in presence of bright Sun shine and chlorophyll to produce carbohydrate (CH_2O) and release O_2. Further, leguminous crops utilize the carbohydrate, water, nitrogen gas (eqn. 2) and hydrogen ions to fix nitrogen in the form of ammonium nitrate and carbon dioxide. Thus, both the processes are interdependent as revealed by **Figure 2**. Understanding of the process encourages one to think of some innovation to bring speed and quantum of the processes and cycle of revolution. Conservation of adequate moisture that enables productivity of carbohydrate, ammonium and oxygen will be highly desirable. The raised bed and furrow racy nature land and water optimizing operation of ultimate green chemistry on the ideal land form of raised bed and furrow should be customized. The revolving attern is irrotational dynamics that keeps the cycle performing its function irrotationally in all seasons all geographical locations and under all crop combinations.

The innovative doctrine of inter cropping opens vistas for development of secondary natural resources of N, P, K, S, O, CO_2 and carbohydrate. It shows how the efficiency of intercropping can be enhanced by nitrogen fixing inoculants, PSB, tricoderma for weed control in one operation *ie* preparation of aerobic compost and its application in the field. Creation of aerobic condition is pre requisite for inter cropping. Hence, it demands consideration of creating well drained condition even where there is lack of irrigation, as exists in Africa. The application of new practice of ultimate irrigation (Yadav, 2015b) protects crops from the drought thus; it ensures crops' successful harvest under all conditions. Recently, lot of emphasis is being given to launch crop insurance scheme, which will involve lot of justification to make justified payment to compensate the loss. It involves exchequer to company/ government for extra budget. Little fraction of the budget on inter cropping based on the doctrine will automatically ensure sustainable yield and bring several other associated benefits such as freedom from adversity of price

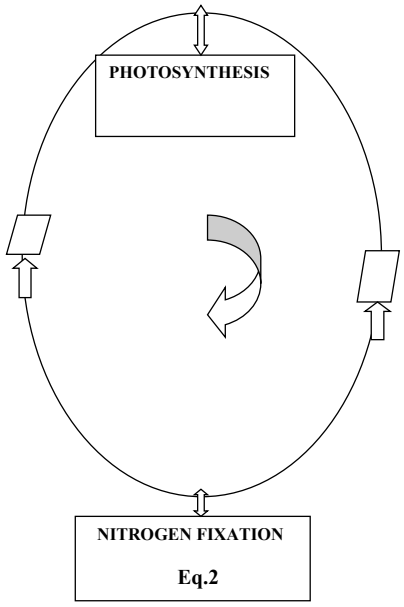

Figure 2 Irrotational cycle of photosynthesis and nitrogen fixation.

rise, GHG emission reduction, protection of land degradation on account of fertility loss.

Sole cropping demands excessive input of nitrogenous inorganic fertilizers. No centralized treatment of sewage in the rural area causes excessive build-up of nitrate in water bodies as well as ground water. Nitrate is the most common chemical contaminant in the world's groundwater aquifers harmful to human health. Its intake in humans is via drinking water and food and might affect the thyroid gland function. Gupta dealt with in detail the crop improvement program to take care of environmental disorders. The crop improvement program is long time taking development, whereas, intercropping will make debut without waiting time. Therefore, correct practice of intercropping will ameliorate the nitrate and iodine related problem to some extent.

Review of some studies revealed that there is great scope to capitalize the nitrogen fixation and phosphate solubilisation by inclusion of cow pea in inter cropping as pulse crop in the rainy season. It gives an indication that relative evaluation of performance should be carried out on different pulses in fixation of nitrogen and phosphate solubilisation. The use of inter cropping with cow pea will enhance yield advantages in racy nature land formation practice.

Conclusion

The inter cropping doctrine evolved by innovative application of scientific facts of management of nitrogen cycle, sulphur cycle, is new technology to bring the maximum production/ha, be it cereals, oil seed or pulse itself and generate multiple benefits and conserve resources for present and posterity. The yield plateaus and direction of agriculture practices transformed from empirical to quantum mechanics of fixed mode agriculture. It requires optimization of various constituent components. The research has potential to bring new agriculture world sufficient quantity, quality and biodiversity and protection of environment free of nitrous oxide emission.

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