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Organic Farming over Chemical Farming in Sustainable Agricultural

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ABSTRACT

Agriculture lies at the heart of Indian civilization. The goal of sustainable agriculture is to integrate all factors into a production system that is appropriate for the environment, people, and local economic conditions. Another issue of great concern was the sustainability of soil productivity as land began to be intensively tilled to produce higher yields under multiple and intensive cropping systems. Water logging and secondary salinization have been the banes associated with excess and irrational irrigation. Groundwater table declined sharply as more and deeper bore wells were drilled. Recharging of groundwater has also been reduced due to severe deforestation. Indiscriminate use of chemical pesticides to control various insect pests and diseases over the years has destroyed many naturally occurring effective biological control agents. Sustainable organic farming practices needs proper eco-friendly pest and disease management practices in addition to balanced nutritional supplement to improve the quality and quantity of the agricultural outputs. Homemade bio-pesticides are prepared by household members using local resources without having any scientific study or research. Homemade bio-pesticides are always environment friendly, safe, low cost or free of cost locally available resources utilization system through engaging family labor. The common understanding on homemade bio-pesticides and organic pest management was very positive. Both preventive and control measures were taken by the farmers in the study area. Sustainable organic agriculture is not a prescribed set of specific practices; rather, it is an integrated system that considers a more complete account of both the costs and benefits of agriculture as it applies to environmental, social, and financial well-being of Indian farmers.

Keywords: Natural farming; organic agriculture practices; ayurvedic farming; sustainable agriculture; vrakshaayurveda

1. INTRODUCTION

A diet based on organic products claims to provide health benefits due to the higher concentration of nutritional compounds compared to conventional ones, and the absence of pesticide residues [1]. The present challenge of feeding the world requires new strategies to not only food security which is surely based on food availability and access, but also on food safety and nutritional quality. Organic production systems may be a way to ensure the sustainability of production, allowing preservation of natural resources for present and future generations, while providing a high quality and long shelf life of the product [2]. Agriculture plays a vital role in a developing country like India. Apart from fulfilling the food requirement of the growing Indian population, it also plays a role in improving economy of the country. The Green Revolution (GR) technology adoption between 1960 to 2000 has increased wide varieties of agricultural crop yield per hectare which increased 12-13% food supply in developing countries. South east Asia and India were the first developing countries to show the impact of GR on varieties of rice yields [3]. Use of Biopesticides and Biofertilizers can play a major role in dealing with these challenges in a sustainable way [4]. The global population will grow to 10.12 billion by 2100 [5]. In order to fulfill the food demand of growing population; higher and advance productive agricultural materials are required [5]. In all successful biocontrol programs; most important parasitoids are Hymenoptera and predators (*Neuroptera, Hemiptera and Coleoptera)*. Globally more than 125 species of natural enemies are commercially available for biological control programs such as *Trichogramma spp.*; *Encarsia formosa Gahan,* and *Phytoseiulus persimilis Athias- Henriot* [6].

1.1 Homemade Plant Protection Agents

The use of homemade bio-pesticides in the farming practices is age old practice. It is very much friendly environment and can obtain from nature directly. It is an environment friendly, low cost technology without a negative effect on human health, plants and soils. Bio-pesticides are derived from natural materials such as animals, plants, bacteria, and minerals. Bio-pesticides tend to be less toxic, more quickly biodegradable, and more targeted to the specific pest [8].

Table 1. Some plant products used against target specific pests. [7]

Plant product used as biopesticides	Target pest
Limonene and Linalool	Fleas, aphids and mites, also kill fire ants, several types of flies, paper waspsand house crickets.
Neem	A variety of sucking and chewing insect.
Pyrethrum/pyrethrins	Ants, aphids, roaches, fleas, flies, and ticks.
Rotenone	Leaf-feeding insects, such as aphids, certain beetles(asparagus beetle, bean leaf beetle, Colorado potato beetle, cucumber beetle, flea beetle,

	strawberry leaf beetle, and others) and Caterpillars, as well as fleas lice on animals.
Ryania	Caterpillars (European corn borer, corn earworm and others) and thrips
Sabadilla	Squash bugs, harlequin bugs, thrips, caterpillars, leaf hoppers, and stink bugs.

1.2 Organic Production System

Organic standards include a well-defined set of practices and a list of technical tools that are permitted by regulations (i.e., Reg n.889/08 in UE and the National Organic Program in U.S.). A diet based on organic products claims to provide health advantages due to the higher concentration of nutritional compounds compared to conventional ones, and the absence of pesticide residues [9]. The present challenge of feeding the world requires new strategies to ensure food security which is surely based on food availability and access, but also on food safety and nutritional quality. Organic production systems may be a way to ensure the sustainability of production, allowing preservation of natural resources for present and future generations, while providing a high quality and long shelf life of the product [10].

2. APPROACHES FOR ORGANIC FARMING

2.1 Current State of Pesticide Used

Melting glaciers release previously ice-entrapped chemicals to the surrounding environment. As glacier melting accelerates under future climate warming, chemical release may also increase [11]. This is a review of studies conducted earlier on the state of pesticide and biopesticide usage. Pesticides were quantified in air, lake water, glacial meltwater, and streamwater in the catchment of Lake Brewster, an alpine glacier-fed lake located in the Southern Alps of New Zealand [12]. Two historic-use pesticides (endosulfan I and hexachlorobenzene) and three current-use pesticides (dacthal, triallate, and chlorpyrifos) were frequently found in both air and water samples from the catchment [13]. A multimedia environmental fate model was developed for these five chemicals in Brewster Lake [14]. Modeling results indicated that seasonal lake ice cover melt, and varying contributions of input from glacial melt and streamwater, created pulses in pesticide concentrations in lake water. Under future climate scenarios, the concentration pulse was altered and glacial melt made a greater contribution (as mass flux) to pesticide input in the lake water [15]. Concrete samples from demolition waste of a former pesticide plant in Sweden were analysed for total contents and leachate concentrations of potentially hazardous inorganic substances, TOC, phenols, as well as for pesticide compounds such as phenoxy acids, chlorophenols and chlorocresols. Leachates were produced by means of modified standard column leaching tests and pH-stat batch tests. Due to elevated contents of chromium and lead, as well as due to high chloride concentrations in the first leachate from column tests at L/S 0.1, recycling of the concrete as a construction material in groundworks is likely to be restricted according to Swedish guidelines. The studied pesticide compounds appear to be relatively mobile at the materials own pH>12, 12, 9 and 7. Potential leaching of pesticide residues from recycled concrete to ground water and surface water might exceed water quality guidelines for the remediation site and the EU Water Framework Directive. Results of this study stress the necessity to systematically study the mechanism behind mobility of organic contaminants from alkaline construction and demolition wastes rather than rely on total content limit values [16]. Sorption is a key process in the distribution of substances between environmental compartments in marine ecosystems. Two persistent organic pesticides, also known as toxaphene congeners, namely B8-1413 (P26) and B9-1679 (P50), are of special interest because they are not detected in sediments while relatively concentrated in marine mammals. Sorption-desorption, entrapment and competition behaviors of these pesticides onto marine sediments were studied to explain their environmental distribution. However, the sorption-desorption investigations indicate that B8-1413/B9-1679 were on average 2.5 times less entrapped in sediments compared to B7-1450, a toxaphene congener known to accumulate predominantly in sediments. These results suggest that the low entrapment of B8-1413 and B9-1679 favor their availability and transfer to biological matrices [17].

Though the use of pesticides has offered significant economic benefits by enhancing the production and yield of food and fibers and the prevention of vector-borne diseases, evidence suggests that their use has adversely affected the health of human populations and the environment. In order to highlight the global distribution of persistent organic pesticides and their impact on neighboring countries and regions, the role of persistent organic pesticides in Indian region is reviewed. Based on a review of research papers and modeling simulations, it can be concluded that India is one of the major contributors of global persistent organic pesticide distribution. This review also considers the health impacts of persistent organic pesticides, the regulatory measures for persistent organic pesticides, and the status of India's commitment towards the elimination of persistent organic pesticides [18]. Rainfall-triggered overflow is a major driver of pesticide input in streams. Only few studies have examined the suitability of passive sampling to quantify such episodic exposures. In this study, we used Empore™ styrene-divinylbenzene reverse phase sulfonated disks (SDB disks) and event-driven water samples (EDS) to assess exposure to 15 fungicides and 4 insecticides in 17 streams in a German vineyard area during 4 rainfall events. Sampling rates ranged from 0.26 to 0.77 L d(-1) and time-weighted average (TWA) concentrations from 0.05 to 2.11 μg/L. The 2 sampling systems were in good agreement and EDS exceeded TWA concentrations on average by a factor of 3. Our study demonstrates that passive sampling is suitable to quantify episodic exposures from polar organic pesticides [19]. Bioconcentration factors (BCFs) measured in the laboratory are important for characterizing the bioaccumulative properties of chemicals entering the environment, especially the potential persistent organic pollutants (POPs), which can pose serious adverse effects on ecosystem and human health. Traditional lethal analysis methods are time-consuming and sacrifice too many experimental animals. In the present study, in vivo solid-phase microextraction (SPME) was introduced to trace the uptake and elimination processes of pesticides in living fish. BCFs and elimination kinetic coefficients of the pesticides were also recorded. Moreover, the metabolism of fenthion was also traced with in vivo SPME. The method was time-efficient and laborsaving. Much fewer experimental animals were sacrificed during the tracing. In general, this study opened up an opportunity to measure BCFs cheaply in laboratories for the registering of emerging POPs and inspecting of suspected POPs, as well as demonstrated the potential application of in vivo SPME in the study of toxicokinetics of pollutants [20].

Selection of pesticides with small ecological footprints is a key factor in developing sustainable agricultural systems. Policy guiding the selection of pesticides often emphasizes natural products and organic-certified pesticides to increase sustainability, because of the prevailing public opinion that natural products are uniformly safer, and thus more environmentally friendly, than synthetic chemicals. We found that in addition to reduced efficacy against aphids compared to novel synthetic insecticides, organic approved insecticides had a similar or even greater negative impact on several natural enemy species in lab studies, were more detrimental to biological control organisms in field experiments, and had higher Environmental Impact Quotients at field use rates. All pesticides must be evaluated using an empirically-based risk assessment, because generalizations based on chemical origin do not hold true in all cases [21].The fluorescence characteristics of carbamate pesticide, namely carbaryl, was studied based on the basic theory that organic molecules can emit fluorescence as they are excited by rays. Consequently, a fluorescence spectrograph was applied to conduct fluorescence spectrum experiments with standard solution of carbaryl and the hydrolyzed carbaryl, the fluorescence spectra were obtained under the condition of different concentration, and the relation between their fluorescence intensity and concentration was also analyzed. The fluorescence spectra are located between 400 and 750 nm and they all have smooth spectrum forms and fine resolution, so the spectra are suitable for qualitative and quantitative analysis of carboxyl. As a result, it is feasible to carry out the detection and analysis of the concerned pesticides in soil directly or indirectly by fluorescence spectral analysis [22]. In the present study, Lu index and distance-based atom type topological index (DAI) previously developed in our team, were introduced and combined with molecular electronegativity chip to characterize quantitative structure-property relationship of GC relative retention time (RRT) for several types of structurally diverse organic pesticides on the four kinds of chromatographic columns. Using multiple linear regression technique, four several-variable models are obtained with the estimations correlation coefficient R (2) being between 0.9655 and 0.9285, and the correlation coefficient (R (2)cv) in the leave-one-out cross-validation procedure are between 0.9560 and 0.9143, respectively. The results in this study indicate that the three topological indices Lu index, DAI, and molecular electronegativity chip can predict the gas chromatographic RRT of organic pesticides with diverse hetero-atoms [23].

In the present paper the basic theory that organic molecules can emit fluorescence as they are excited by ultraviolet rays is described, the molecular structures of a few common pesticides, such as carbamate, benzoylurea and fungicide, are analyzed, and the mechanism of fluorescence generation is also ascertained. Consequently, the theoretic basis for further detection of pesticides by means of fluorescence methods is provided. Moreover a steady-state fluorescence spectrograph was applied to conduct fluorescence spectrum experiments with standard solutions of these pesticides, the fluorescence spectra were obtained, and their fluorescence characteristics were also analyzed. The results indicate that carbamate, benzoylurea and fungicide pesticides may emit strong fluorescence when excited by UV rays under the condition of a certain solvent, their fluorescence spectra are distinct, and the resolution is fine. As a result, it is feasible to carry out qualitative and the quantitative analysis of the concerned pesticides by fluorescence spectral analysis [24].

Advances in research on pollution of organic pesticides (OPs) in surface water, pollution survey and risk assessments of organochlorine pesticides (OCPs) and organophosphorus pesticides (OPPs) of surface water in Hangzhou are conducted. Total concentrations of dichloro-diphenyl-trichloroethane (DDT) and hexachloride-benzene (HCH) in surface water were observed to be 0-0.270 microg/L and 0-0.00625 microg/L respectively. DDE, as a metabolite of DDT and many species of OPP(S) were determined in some samples of surface water. Parathion, the main pollutant among OPPs in surface water of Hangzhou, was observed to be 0-0.445 microg/L. Based on these experimental results, health risk assessments on the organic pollution are developed. It is observed that the total risk "R (T)" at present time of surface water in Hangzhou is mainly contributed by organophosphorus pesticides, especially Parathion; HCH and DDT are not the main contaminants; on the contrary, organophosphorous pesticides, especially Parathion, must be of concern at the present time [27]. A batch reactor was used to determine sorption kinetic parameters (k 2, F, and K*) and the equilibrium sorption coefficient (K). The two-site nonequilibrium (TSNE) batch sorption kinetics model was used to calculate the kinetic parameters. Carbonatic soils contained more than 600 g kg(-1) CaCO3. Sorption is initially very fast up to 3h and then slowly reaches equilibrium. All soil-chemical combinations reached sorption equilibrium after about 24h and all sorption isotherms were linear. An inverse relationship between k3 and K was observed for atrazine and diuron separately in Chekika, Webster, and Lauderhill soils but not in Perrine and Krome soils. The sorption kinetic parameters were used to distinguish the sorption behavior between atrazine and diuron and to identify differences between soils. Using existing literature KOC values in solute transport models will most likely underestimate the mobility of atrazine, diuron, and other neutral organic chemicals in carbonatic soils [28].

We have tested whether some pesticides might cause inner membrane leakage in ML35 Escherichia coli cells, which express beta-galactosidase (lacZ; EC 3.2.1.23) constitutively but lack the permease (lacY) required for substrate entry. The activity of beta-galactosidase (indicative of substrate leakage through the inner membrane) was increased by various concentrations of pesticides, including the organometallic fungicides maneb and mancozeb, the insecticide Thiodan, and the herbicide Ally, as well as by antibiotics such as ampicillin, gramicidin D, and the calcium ionophore A23187. The enzyme activity was increased by up to approximately 30% when the E. coli ML35 strain was exposed to various concentrations (between 50 and 250 ppm) of both fungicides. In parallel with the increase in enzyme activity, both fungicides accumulated in the cells as a function of their concentration. This indicates a different uptake and/or metabolizing strategy by E. coli cells for the two fungicides [29]. The results and especially the high concentrations of DDTs reflect the influence of the industrial and urban wastes in the pollution for the Keratsini harbour environment [30].

A group contribution approach based on atom-type electrotopological state indices for predicting the soil sorption coefficient (log KOC) of a diverse set of 201 organic pesticides is presented. Using a training set of 143 compounds, for which the log KOC values were in the range from 0.42 to 5.31, multiple linear regressions (MLR) and artificial neural networks were used to build the models. The models were validated using two test sets of 20 and 38 chemicals not included in the training set. The statistics for a linear model with 12 structural parameters were, in test set 1,

$r^2 = 0.79$, $s = 0.45$ and, in test set 2, $r^2 = 0.74$, $s = 0.65$. These results clearly show that soil sorption coefficients can be accurately and rapidly estimated from easily calculated structural parameters [31]. The aim of this study was to investigate the sorption behavior and mechanisms of the organic pesticides on soil. To establish the sorption isotherms of six commonly used pesticides (acetochlor, atrazine, diazinon, carbendazim, imidacloprid, and isoproturon), laboratory equilibrium studies were performed at extended concentration ranges on brown forest soil using the batch equilibrium technique. The adsorption processes could be described by a single-step (Langmuir) isotherm for acetochlor and carbendazim, by a two-step curve for diazinon, isoproturon, and atrazine, and by a three-step curve for imidacloprid. A nonlinear mathematical model-derived from the Langmuir equation-has been developed that represents well the detected single-step and multistep shaped adsorption isotherms. The parameters calculated from the equation provide an opportunity to estimate the extent of absorption constant, adsorption capacity, and concentration limit characteristic to the measured stepwise isotherms [32].

We evaluated the feasibility of extracting organic pesticides in soil using a hot-water percolation apparatus at 105 ^{0}C and 120 kPa pressure. Efficiency of the method was assessed by extracting six selected pesticides (acetochlor, atrazine, diazinon, carbendazim, imidacloprid, and isoproturon) from previously equilibrated soil at 13.6-65.8 mg/kg concentration range. Studies were performed on brown forest soil with clay alluviation (Luvisol). The method developed was compared to the traditional batch equilibrium method in terms of desorbed amount of pesticides from soil and extraction time. Desorbed quantities by hot-water percolation were 85% acetochlor, 62% atrazine, 65% carbendazim, 44% diazinon, 95% imidacloprid, and 84% isoproturon, whereas using batch equilibrium method 101, 66, 64, 37, 81, and 90% were desorbed, expressed as the percentage of the adsorbed amount of pesticide on soil following equilibration. The parameters calculated from the equation provide an opportunity to estimate the amount of compound available for desorption, the rate of desorption processes in the studied soil-pesticide-water system, and modeling the leaching process to obtain additional information on the environmental behavior of the examined pesticide [33]. Soil sorption coefficients (K (OC)) of 185 non-ionic organic heterogeneous pesticides have been studied searching for quantitative structure-property relationships (QSPRs). The chemical description of pesticide structure has been made in terms of some molecular descriptors: count descriptors, topological indices, information indices, fragment-based descriptors and weighted holistic invariant molecular (WHIM) descriptors; these last are statistical indices describing size, shape, symmetry and atom distribution of molecules in the three-dimensional space [34].

2.2 Ultimately We Have to Go for Natural Biopesticides

An analytical procedure was developed for the determination of some natural pesticides (piperonyl butoxide, nicotine, rotenone, spinosad, and abamectin B1a) in fruit matrixes. The quick, easy, cheap, effective, rugged, and safe (QuEChERS) method was used for extraction.

Analysis of the extract was performed by LC-electrospray ionization (ESI)-MS/MS. The ions prominent in the ESI spectra were $[M^{+}Na]^{+}$ for abamectin B1a, $[M^{+} NH4]^{+}$ for piperonyl butoxide, and $[M^{+}H]^{+}$ for the rest of the compounds. A Zorbax SB-C18 column was used with a programmed gradient mobile phase consisting of (A) water containing 0.1% formic acid and 5 mM ammonium formate, and (B) acetonitrile containing 2 mM sodium acetate. The method was linear within the investigated concentration range, displaying a calibration curve correlation factor of 0.99. The CVs obtained were below 20%, and recoveries were in the 70-110% range [35]. This paper describes a method for the sensitive and selective determination of two macrocyclic lactones (abamectin and spinosad) and azadirachtin in apple purée, concentrated lemon juice, tomato purée and canned peas. The general sample extraction-partitioning method for our gas chromatography and liquid chromatography multiresidue methods has been used. The analytical procedure involves an extraction with acetone and liquid-liquid partitioning with ethyl acetate/cyclohexane combined in one step. Studies at fortification levels of 2.5-10 microg/kg and 25-100 microg/kg gave mean recoveries ranging from 70-100% for all compounds with satisfactory precision (relative standard deviation (RSD) from 3-20%). The excellent selectivity and sensitivity allows quantification and identification of low levels of pesticides in canned peas, tomato and apple purées (limits of quantitation (LOQs) 1-5 microg/kg) and in concentrated lemon juice (LOQs 2-10 microg/kg). The quantification of analytes was carried out using the most sensitive transition for every compound and by 'matrix-matched' standards calibration [36].

The cyanobacterium Nostoc strain ATCC 53789, a known cryptophycin producer, was tested for its potential as a source of natural pesticides. The antibacterial, antifungal, insecticidal, nematocidal, and cytotoxic activities of methanolic extracts of the cyanobacterium were evaluated. Among the target organisms, nine fungi (*Armillaria sp., Fusarium oxysporum f. sp. melonis, Penicillium expansum, Phytophthora cambivora, P. cinnamomi, Rhizoctonia solani, Rosellinia, sp., Sclerotinia sclerotiorum,* and *Verticillium albo-atrum*) were growth inhibited and one insect (*Helicoverpa armigera*) was killed by the extract, as well as the two model organisms for nematocidal (*Caenorhabditis elegans*) and cytotoxic (*Artemia salina*) activity. To fully exploit the potential of this cyanobacterium in agriculture as a source of pesticides, suitable application methods to overcome its toxicity toward plants and nontarget organisms must be developed [37]. Six compounds, representing the mono-tetrahydrofuran (THF) (gigantetrocin A, annomontacin), adjacent bis-THF (asimicin, parviflorin), and nonadjacent bis-THF (sylvaticin, bullatalicin) classes of annonaceous acetogenins, were compared with technical grades of synthetic amidinohydrazone (hydramethylnon), carbamate (propoxur, bendiocarb), organophosphate (chlorpyrifos), and pyrethroid (cypermethrin) insecticides to determine their dietary toxicities to insecticide-resistant and insecticide-susceptible strains of the German cockroach, *Blattella germanica (L.)*. The acetogenins caused high percentages of mortality and delays in development of the 5th instars of both strains. Low resistance ratios values for 2nd instars ranged from 0.9 to 2.2 with the natural acetogenins and from 1.0 to 3.8 with the synthetic compounds; the 5th instars ranged from 0.2 to 3.9 with the natural acetogenins and from 0.6 to 8.0 with the synthetic compounds. Insecticidal properties and characteristics of acetogenins and the possible use of acetogenins in baits for cockroach control are discussed [38].

Five commercial preparations of natural pesticides were tested for in vitro compatibility with muscardine fungi, *Beauveria brongniartii* and *Metarhizium anisopliae*. Neemark (azadirachtin) was found compatible with both the fungi. Phytoallexin, the natural fungicide, significantly inhibited the growth of both the fungi, while other natural pesticides showed moderate to severe inhibition [39]. Based upon the US National Toxicology Program (NTP) rodent carcinogenicity data base, CASE, an artificial intelligence structure-activity evaluation method, predicts that a large proportion of natural pesticides present in edible plants are rodent carcinogens [40]. In this review, some common food plants and their toxic or otherwise bioactive components and mycotoxin contaminants have been considered. Crucifers contain naturally occurring components that are goitrogenic, resulting from the combined action of alkyl isothiocyanate, goitrin, and thiocyanate. Celery field workers and handlers continually have photosensitization problems as a result of these indigenous celery furanocoumarins. Since there is no regulatory agency or body designated to oversee potential toxicological issues associated with naturally occurring toxicants, photodermatitis continues to occur from celery exposure. Sweet potatoes contain phytoalexins that can cause lung edema and are hepatotoxic to mice. At least one of these, 4-ipomeanol, can cause extensive lung clara cell necrosis and can increase the severity of pneumonia in mice. Some phytoalexins in sweet potatoes are hepatotoxic and nephrotoxic to mice. The common mushroom *Agaricus bisporus* contains benzyl alcohol as its most abundant volatile, and *A. bisporus* and *Gyromitra esculenta* both contain hydrazine analogues. Mycotoxins are found in corn, cottonseed, fruits, grains, grain sorghums, and nuts (especially peanuts); therefore, they also occur in apple juice, bread, peanut butter, and other products made from contaminated starting materials [41].

3. CONCLUSION

The interest in organic agriculture in developing countries is growing because it requires less financial inputs and places more reliance on natural and human resource available. Organic farming on small land holdings, especially under rain fed zones, tribal areas and North West to North East Himalayas still will go to long way in promoting organic farming in India. In order to address the aforesaid challenges in a better way, integration of these systems and develop package of Jaivik Krishi (organic farming), which can be promoted in different parts of the country by the common Indian farmers. It is interesting to record that in all four systems “COW” particularly those with hump (indigenous breed) is one of the key components, hence provision of at least one cow per hectare need to be promoted for Jaivik Krishi activities in organic farming. Suggestive evidence indicates that organic food consumption may reduce the risk of allergic disease and of overweight and obesity, but residual confounding is likely, as consumers of organic food tend to have healthier lifestyles overall. Organic agriculture has been neglected in the agricultural policy in past years, and therefore there was less government assistance for the promotion of organic agriculture, as it exists for the conventional agriculture in the form of subsidies, agricultural extension services and official research. But the present Government is giving proper encouragement for organic farming; thus it will progress tremendously in India, especially in the dry land regions of the country, taking advantage of the diverse soil and climatic conditions for the sustainable agricultural practices.

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