Research Article

Impact of Clean Food Program on Reduction of Pesticide Residue in Vegetables grown under Irrigated Ecosystem

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Abstract

The use and abuse of pesticides in agriculture has been increasing the risk of food chain contamination. Sustainable agriculture that serves to reduce/ eliminate the use of pesticides and thereby the threat of pesticide residue in the end product; has become crucial to address the issue. In this background, 'Clean Food Program' was taken up under the IBM-IORF Sustainability Project in the Nadia District of West Bengal (India) in 2021, towards the objective of reducing/ eliminating pesticides from crop production without incurring crop loss and without increasing the cost of production. The objective was driven by Inhana Rational Farming (IRF) Technology, through its unique approach of plant health management. Analysis of more than 200 samples of conventionally grown vegetables using Colorimetric Assay Test revealed pesticide residues of >0.01ppm in 34.93% samples. Moreover, multiple pesticide groups were detected in 51% of the pesticides contaminated vegetables. 'Clean Food' Program was found to reduce the risk of pesticide contamination by more than 80%, even for high risk vegetables like pointed gourd, brinjal, chilli and okra; and residue, in terms of single pesticide group was detected in a mere 3.8% samples. The study exposed the hidden risk of food chain toxicity under conventional farmers' practice and highlighted the need of more safe and sustainable agricultural initiatives.

Keywords: Colorimetric assay test, Inhana Rational Farming (IRF) Technology, food safety, maximum residue limit

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Introduction

The growing demand for food commodities and the ensuing climate change impact has led to a significant increase in pesticide usage under the conventional crop production system [1]. Globally the pesticide usage has increased from 1.2 to 1.8 kg/ha when compared with usage in the 1990s [2]. Pesticide residue levels in food commodities are thus a major concern owing to their inherent toxicity and bioaccumulation potential striking a direct implication on human health [3], ecological imbalance and loss of biodiversity. A recent study done by the Ministry of Agriculture, Govt. of India showed that more than 18.7 % food items have pesticide residues [4]. West Bengal being an agricultural intensive state, pesticide usage in 2021-22 at 0.69 kg/ha was about 52.6% higher than the average use in India (0.45 kg/ha) [5,6]. Sustainable Pest Management has been indicated by the FAO as a solution to minimize the pesticide risks to human health and the environment. However, references are lacking regarding the impact of sustainable cultivation practice in respect of reducing the pesticide residues in crop.

In this background, the 'Clean Food' Program was initiated towards development of pesticide free food product, for preservation of soil and ecology and to empower the small and marginal farmers through better livelihood support [7]. The approach was driven by Inhana Rational Farming (IRF) Technology, which served to reduce/ eliminate pesticide use without incurring crop loss and without increasing the cost of production. In the present study, comparative pesticide residue analysis was done for the vegetables grown under 'Clean Food' Program vs. vegetables available in the conventional market; in order to evaluate the impact of safe and sustainable agriculture in respect of food safety and elimination of the risk of pesticide contamination in vegetables.

Materials and Methods

Development of 'Clean Food' (CF) was initiated under IBM Sustainability Project entitled 'Adoption of a Cluster of Villages for Agricultural Sustainability and Food Security through Clean Food Program'. It was conducted during the period 2021-23 by Inhana Organic Research Foundation (IORF); in scientific collaboration with Krishi Vigyan

Kendra (Nadia, BCKV, ICAR). The project comprised five villages namely Satyapole, Bhabanipur, Panchkahaniya, Dhopagachi and Bansbona in the Haringhata block of Nadia district of West Bengal, India. A model farm was also set up in the project area to serve as a Sustainable Agriculture training and demonstration center for the local farmers.

Clean Food Program

Clean Food is developed following a resource independent agricultural model under IRF Technology, executed through the adoption of Inhana Plant Health Management (IPHM).

The concept of 'Clean Food' is based on a scientific hypothesis that the relationship between a plant and pest is purely nutritional. The life time research of plant scientist F. Chaboussou showed that application of chemical fertilizers, specially N-fertilizers along with depressed plant metabolism enhance the free amino acids and free sugar pools in the plant cell sap which serve as the ready food for the pest (**Figure 1**) [8].

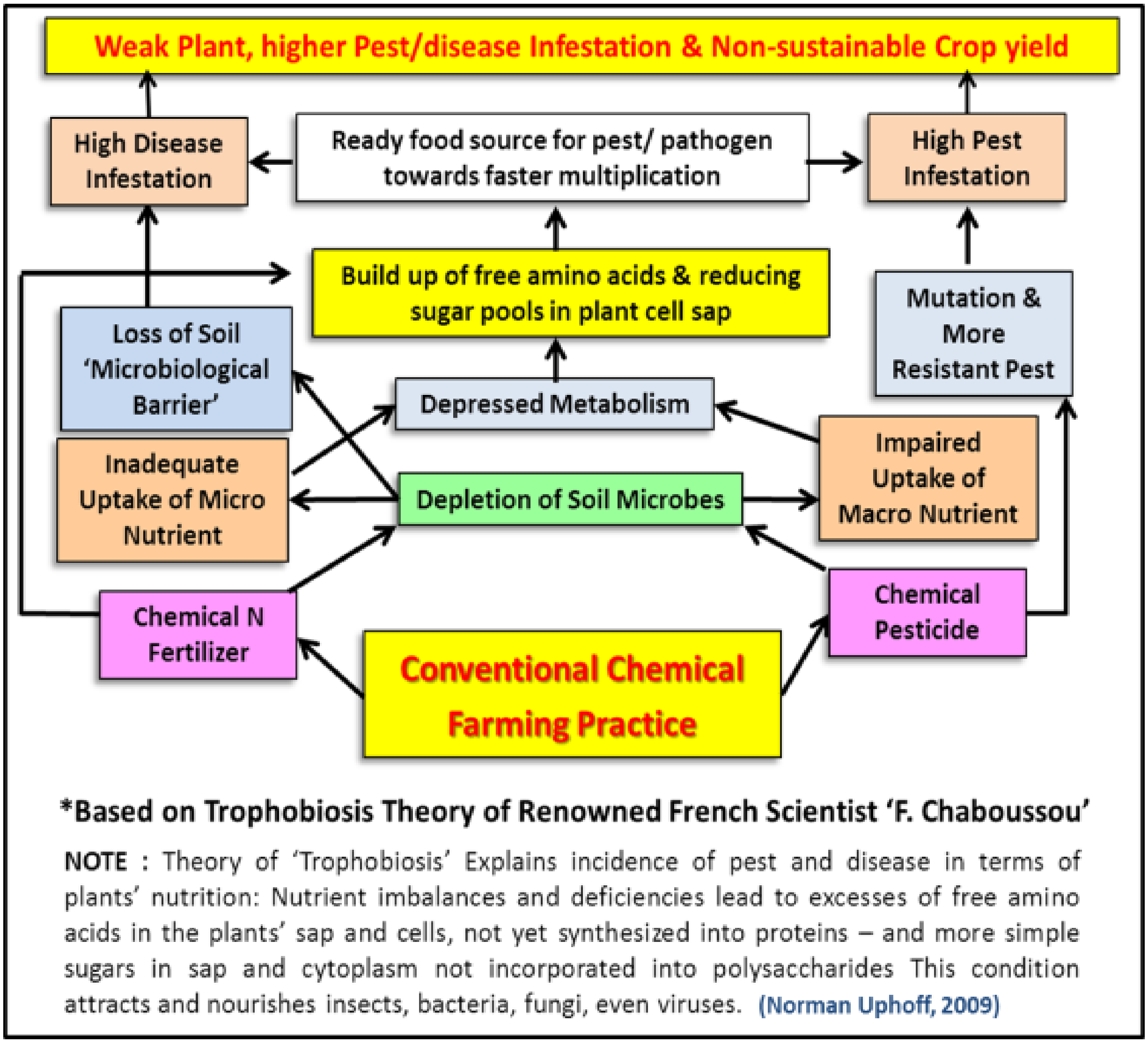

Figure 1 Weak plant system is the root cause for higher pest / disease infestation

Hence, if pesticide use is to be reduced/ eliminated from the crop production system, then first pest need to be reduced and for that the ready food source need to be cut off. This can be only ensured through development of 'Healthy Plants'. Driven by Inhana 'Energy Solutions' IPHM is a 1st ever approach in Indian Agriculture towards development of 'Healthy Plants' through activation of plant physiology for enhanced plant metabolism and biochemical secretions [9]. This approach on one hand enhances the agronomic efficiency of the plants and cuts down the formation and accumulation of free amino acids and free sugar pools in the plant cell sap on the other, thereby reducing the ready food source for the pest (**Figure 2**). Hence, activation of plant physiology ensures the dual premise of crop sustainability and higher plant immunity towards pest and disease leading to elimination of chemical pesticides.

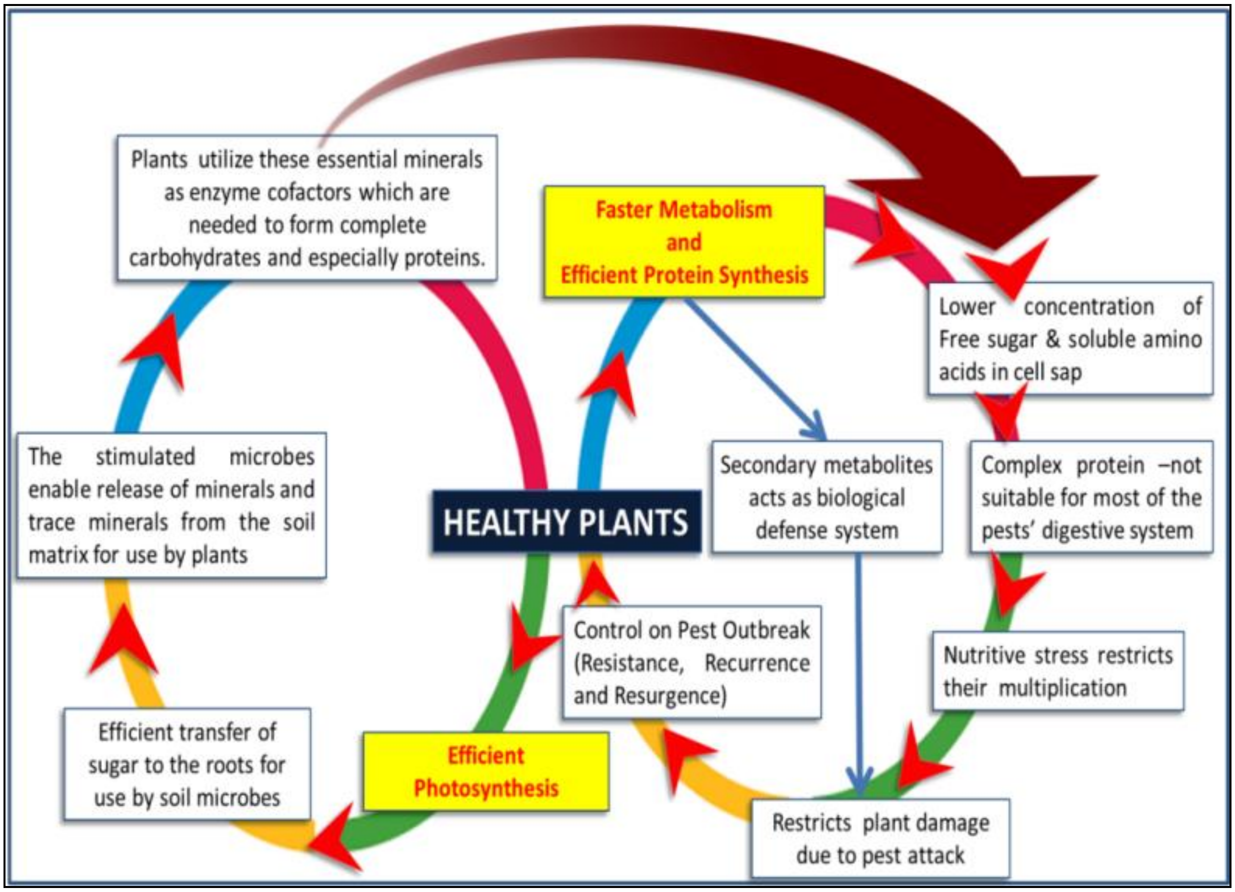

Figure 2 Pest Management through Plant Health Management: How the concept works under IRF Technology

Analysis of Pesticide Residue

Vegetable samples were collected from project villages and from different vegetable markets in Kolkata in 2023. Samples were tested for six major pesticide groups *viz*. Organochlorine, Organophosphate, Carbamate, Synthetic Pyrethroids and Nicotinoids which represent more than more than 650 pesticides formulations covering more than 90 % major insecticides, fungicides and herbicides use in India [8]. QuECHERs method was adopted for processing of the vegetable samples for pesticide residue analysis [10]. Pesticide residue was analyzed as per Colorimetric Assay Test which was jointly developed by IORF, Kolkata and KVK (Nadia, BCKV, ICAR) [11].

Result and Discussion

Pesticide residue analysis was taken up in respect of 18 major vegetables sourced from the project area and from the conventional vegetable markets in Kolkata. Total 584 vegetable samples were taken for Colorimetric Pesticide Assay Test, among which 218 sample were sourced from vegetable markets, 204 samples were collected from 'Clean Food' Project area, 108 samples from Clean Food Model Farm within 'Clean Food' Project area and another 54 samples were sourced from certified organic selling points.

Safety aspect of 'Clean Food' was evaluated following the regulation of Codex Alimentarius Commission (CAC) [12] and the Food Safety and Standards (Contaminants, Toxins And Residues) Regulations (2011)[13]; developed by Food Safety and Standards Authority of India (FSSAI); according to which the maximum residue limit (MRL) for vegetables is 0.1 ppm (for individual pesticides). However, for 'Clean Food' 0.1 ppm was considered as the MRL for the total pesticide residues in a particular pesticide group (irrespective of the number of pesticides in that group), to enable more stringent evaluation of its safety aspect.

Out of the total 584 vegetable samples analyzed for pesticide residues (**Table 1**), 83 samples (14.21 %) showed the presence of at least one group of pesticides with an MRL >0.1 ppm. In respect of the vegetable samples collected from the conventional markets, pesticide residue was detected in 34.93 % samples. Based on the risk of pesticide contamination these vegetables could be categorized under three groups (i) Low to no risk zone (presence of at least one group of pesticides with MRL >0.1 ppm in <20 % samples) : peas, cabbage, cauliflower, potato, onion, yam, spinach and coriander; (ii) Moderate risk zone (presence of at least one group of pesticides with MRL >0.1 ppm in 20

- 50 % samples) : French bean, cucumber, carrot, tomato, potato, pumpkin and ridge gourd and (iii) High risk zone (presence of at least one group of pesticides with MRL >0.1 ppm in >50 % samples) : pointed gourd, brinjal, chilli and okra.

Table 1 Segment wise vegetable samples taken for pesticide residue analysis and samples having the presence of atleast one group of pesticides with an MRL > 0.1 ppm

Type of Vegetables	Source of Vegetables				
	Market Source	Clean Food Project	Model Farm	Certified Organic	Total Samples
Brinjal (*Solanum melongena L.*)	17 (11)	17 (2)	6 (0)	3(0)	43 (13)
Tomato (*Solanum lycopersicum*)	11 (3)	11 (1)	6 (0)	3(0)	31 (4)
Potato (*Solanum tuberosum*)	15 (2)	15 (1)	6 (0)	3(0)	39 (4)
Green Chilli (*Capsicum annuum*)	14 (9)	9 (1)	6 (0)	3(0)	32 (10)
Cucumber (*Cucumis sativus*)	12 (5)	7 (1)	6 (0)	3(0)	28 (6)
Pumpkin (*Cucurbita pepo L.*)	9 (3)	9 (0)	6 (0)	3(0)	27 (3)
Pointed gourd (*Trichosanthes dioica Roxb.*)	15 (10)	15 (2)	6 (0)	3(0)	39 (12)
Ridge Gourd *(Luffa acutangula (L.) Roxb.*)	9 (3)	9 (0)	6 (0)	3(0)	27 (3)
Peas (*Pisum sativum*)	9 (1)	9 (0)	6 (0)	3(0)	27 (1)
French beans (*Phaseolus vulgaris*)	9 (4)	9 (1)	6 (0)	3(0)	27 (5)
Cabbage (Brassica oleracea var. capitata)	17 (2)	16 (0)	6 (0)	3(0)	42 (2)
Cauliflower (*Brassica oleracea var. botrytis*)	17 (2)	16 (0)	6 (0)	3(0)	42 (2)
Okra (*Abelmoschus esculentus*)	14 (8)	14 (2)	6 (0)	3(0)	37 (10)
Onion (*Allium cepa*)	12 (2)	12 (0)	6 (0)	3(0)	33 (2)
Carrot (*Daucus carota subsp. Sativus*)	13 (4)	13 (1)	6 (0)	3(0)	35 (5)
Spinach (*Spinacia oleracea*)	9 (0)	9 (0)	6 (0)	3(0)	27 (0)
Yam (*Dioscorea*)	7 (0)	7 (0)	6 (0)	3(0)	23 (0)
Coriander (*Coriandrum sativum*)	9 (1)	7 (0)	6 (0)	3(0)	25 (1)
Total	218 (71)	204 (12)	108 (0)	54(0)	584 (83)

Note : Figures in parenthesis represents the no. of samples that have atleast one group of pesticides with MRL > 0.1 ppm

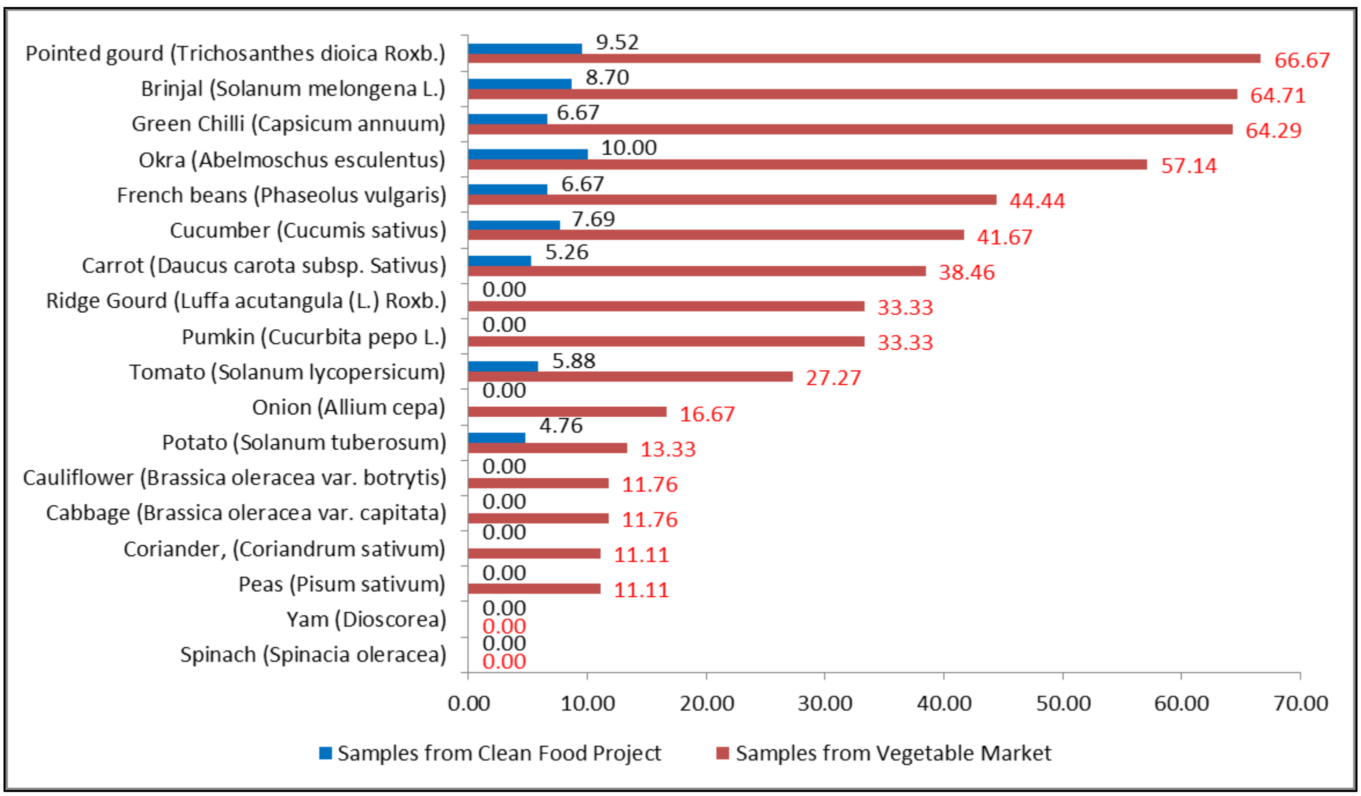

Figure 3 Categorization of the different vegetables in respect of the presence of pesticide residue, as per Standards of Codex Alimentarius FAO-WHO & FSSAI (> 0.10 ppm)

Evaluation detected the presence of pesticide residue (one pesticide group with MRL >0.1 ppm) in only 3.85% samples; out of the total 312 vegetable samples collected from the 'Clean Food' project area (including the model farm). Most significantly, out of the 18 different types of vegetables, 9 types of vegetables (i.e., about 50%) were found to be completely clean (No pesticide residue) (**Figure 3**).

Also, for the categories of vegetable that came under the high risk zone, those collected from the conventional markets showed risk of contamination in 63.3% samples while the same was observed for only about 12.7% samples collected from the 'Clean Food' Project Area. The finding indicated that adoption of this safe and sustainable initiative led to a significant (80 %) reduction in the risk for pesticide contamination even for vegetables under high risk category.

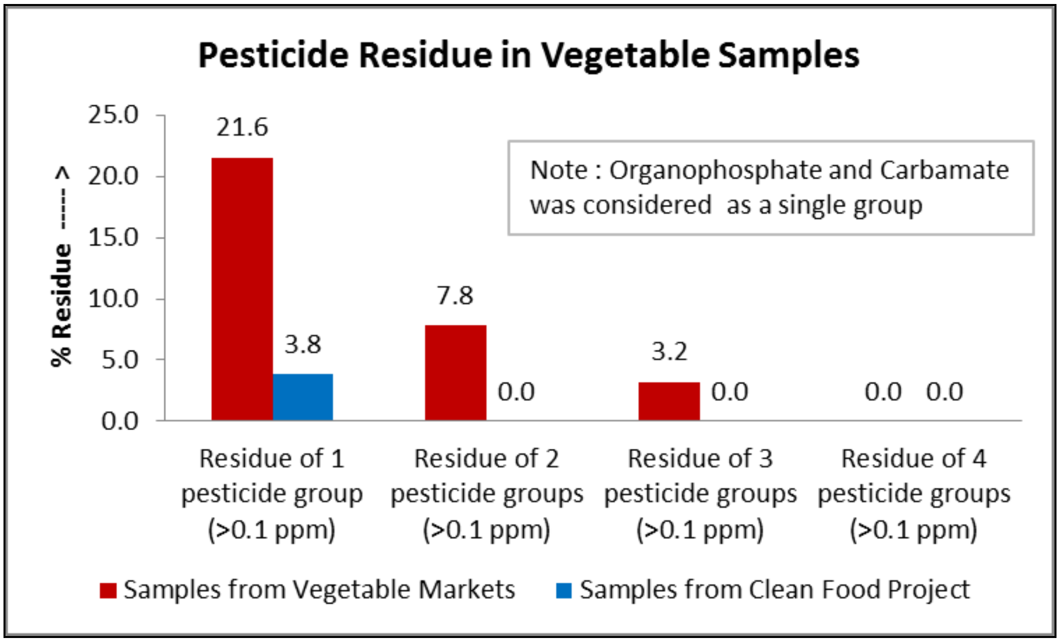

Figure 4 Comparative study of presence of pesticide residue in conventional vegetables *vis-a-vis* those grown in the project area.

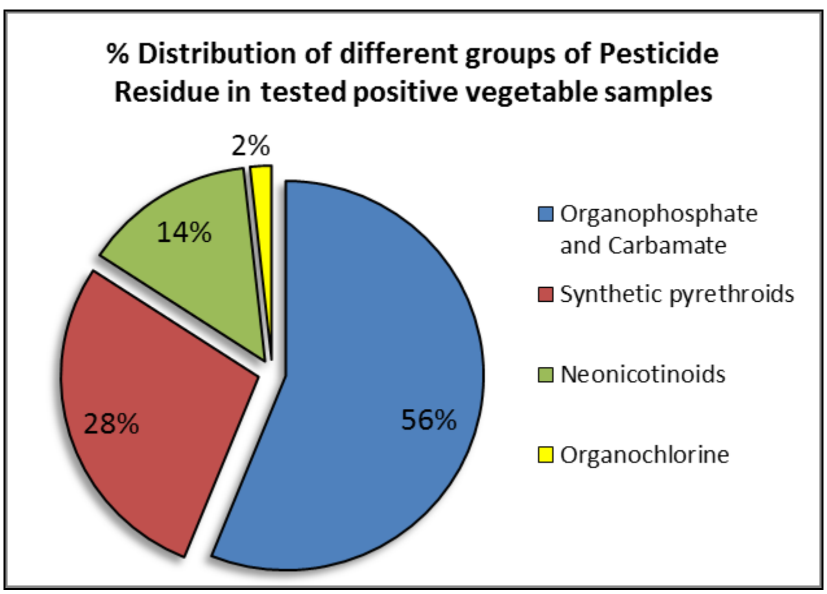

Figure 5 Comparative presence of different pesticides groups in the vegetables tested positive for pesticide residues.

Comparative study w.r.t. the number of pesticide groups present, interestingly revealed single pesticide group in about 21.6 % samples and two to three groups (**Figure 4**) in 7.8 and 3.2% samples (respectively); collected from the conventional vegetable markets. In contrast, presence of pesticide residue, that too single pesticide group was detected in only about 3.8% vegetable samples; collected from the 'Clean Food' project area

Percent distribution of different groups of pesticides in positive tested vegetable samples indicated residues of Organophosphate and Carbamate groups in 56%, Synthetic pyrethroids in 28%, Neonicotinoids in 14% and Organochlorine in 2% cases (**Figure 5**).

Conclusion

The study is perhaps a pioneering initiative which indicated that adoption of Sustainable Agriculture in terms of 'Clean Food' program had a significant impact on the overall pesticide usage in the project area, leading to development of Safe Food. This could be primarily due to focus on Plant Health Management under IRF Technology, that led to an improvement in plant immunity leading to a considerable reduction in pest pressure during crop production, which naturally lowered the requirement for pesticide application; even in the case of high pest prone crops like brinjal, okra, chilli, etc. Thus the study on one hand could serve as an eye opener in respect of the underlying threat to human health due to the increasing risk of pesticide contamination in food chain, while also demonstrating the relevance of undertaking more and more safe and sustainable initiatives in agriculture for food safety, ecological sustenance and to sustain farmers' livelihood.

At the same time the above can serve as a benchmark study to attend the objectives of Sustainable Developmental Goals 2 (SDG2) where safe and sustainable food production is the prime focus. Moreover, the highest investment gap in respect of SDG 2 itself indicates the lack of technical intervention and the need for more scientific efforts towards fighting hunger, food and nutritional in-security. The present study can guide sustainable agriculture programs in respect of reducing the dependency on chemical pesticides while also ensuring crop sustainability. Moreover the technique adopted for pesticide residue analysis in this study can revolutionize the Food Safety Authentication aspect in the entire Indian Agricultural scenario in respect of practical feasibility and economic viability and thereby empower the future sustainable agriculture initiatives.

Acknowledgement

The authors are thankful to IBM Sustainability Platform for providing financial assistance for the Safe & Sustainable 'Clean Food' Project, under which this study was conducted.

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Publication History

Received	02.06.2023
Revised	12.10.2023
Accepted	14.10.2023
Online	31.12.2023