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Adoption of Chemical Pesticides Under Commercial Vegetable Cultivation in Sri Ganganagar District of Rajasthan

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ABSTRACT

The study was conducted in Sri Ganganagar district of Rajasthan to assess the extent of use of chemical pesticides under commercial vegetable cultivation. The primary data were collected from 100 farm households across 18 villages from 2016 to 2019. Chemical insecticides were used by all farmers whereas biopesticides and botanical pesticides were used by <5% for insect pest control in vegetables. The average number of chemical pesticide sprays in a crop cycle was 14, 15, 15 and 13 in cauliflower, cabbage, tomato and pea crops respectively. Average quantity of chemical pesticides used was 4.23, 3.87, 5.16 and 3.47 kg active ingredient per hectare in cauliflower, cabbage, tomato and pea crops respectively. The study highlights the overuse and misuse of chemical pesticides in vegetable crops where the economic part is edible unlike cotton where the economic part is non-edible. The direct negative impact of chemical pesticides on health of farm workers is estimated in the paper.

INTRODUCTION

It is reported that pathogens and pests cause global losses ranging from 10-28 per cent in wheat, 25-41 per cent in rice, 20-41 per cent in maize, 8-21 per cent in potato and 11-32 per cent in soybean (Savary et al., 2019). Pesticides are used for increasing the agricultural productivity and safeguarding the public health. The industrialization of agriculture has favoured the use of plenty of agrochemicals including fertilizers, pesticides, micronutrients and plant growth regulators in the agricultural fields. There are 299 insecticides/ pesticides registered in India as on 01/07/2021 (MoA, 2021a). During 2020-21, Maharashtra had the highest total pesticide consumption followed by Uttar Pradesh, Punjab and Haryana (MoA, 2021a). Punjab had the greatest per acre pesticide consumption (0.74 kg), followed by Haryana (0.62 kg), and Maharashtra (0.57 kg) during the year 2016-17 (Subash et al., 2017). However, per hectare use of pesticide in India is much lower as compared to other countries like China (13.06 kg/ha), Japan (11.85 kg/ha), Brazil (4.57 kg/ha) and other Latin American countries (FAO, 2018).

Agrochemicals used to increase agricultural productivity, were also associated with many direct and indirect negative impacts on human health and environment. There are growing concerns of pesticide risks to human health, natural environment and ecosystems (Atreya et al., 2012). These effects are increasingly manifested in loss of working efficiency of farm workers resulting in higher cost of production. The increased use of pesticides, deteriorating ecosystem health has advocated the need to change traditional and external input use in agriculture towards safe and sustainable production (Bhurtyal et al., 2016). In this context, the present study was aimed at measuring the extent of use of pesticides in commercial vegetable production and its direct impact on human health.

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METHODOLOGY

Sri Ganganagar district in Rajasthan state was purposively selected for the study owing to maximum area and commercial production of selected vegetables (cabbage, cauliflower, tomato and peas). These vegetables are being cultivated since late sixties and early seventies until now in the study area. In the second stage, two blocks namely Ganganagar and Raisinghnagar were selected based on highest area and production. From these two blocks, 18 villages were selected using stratified proportional sampling method. Hundred farm households were selected randomly from these 18 villages in proportion to the area under vegetables in each village. Cauliflower, cabbage, tomato and peas were cultivated by 50, 42, 37 and 34 farm households (HH) respectively among these 100 farm HHs. Interview schedule was developed specifically for this study. Primary data were collected from 2016 to 2019 using personal interview method on vegetable cultivation practices, plant protection techniques and other variables. The cumulative square root frequency method (Singh and Mangat, 1995) was used for the construction of strata. The farmers with land up to 2.5 ha were categorized as small farmers and those having land more than 2.5 ha as large farmers. 86 per cent farmers in Ganganagar block and 77 per cent farmers in Raisinghnagar block were small farmers. At the district level, 81 per cent farmers were small farmers and remaining 19 per cent were large farmers.

The primary data were corroborated/ validated through focussed group discussions with key informants in each village and scientists from Krishi Vigyan Kendra and agriculture officers working in Sri Ganganagar district. Published secondary sources were also used.

RESULTS AND DISCUSSION

Sri Ganganagar district in Rajasthan falls under Irrigated North West Plain Zone-1b (RJ-2) and is blessed with deep loamy soil (Agriculture Contingency Plan, 2021; KVK Sri Ganganagar, 2021). The mean rainfall in zone is 32.6 cm of which 75 per cent is received in the month of July to September. The major crops cultivated in the district are cotton (*Gossypium* sp.), groundnut (*Arachis hypogaea*), rice (*Oryza sativa*), pearl millet (*Pennisetum glaucum*), green gram (*Vigna radiata*) and guar (*Cyamopsis tetragonoloba*) in *kharif* season and wheat (*Triticum* sp.), barley (*Hordeum vulgare*), gram (*Cicer arietinum*) and rapeseed and mustard (*Brassica* sp.) under *rabi* season. More than 80 per cent arable land is under irrigation. The major source of irrigation in the district is the canal water (supplied by Indira Gandhi Nahar Project, GANG Nahar and Bhakra Nangal dam) and a very small portion is irrigated through tubewells. The agriculture in the district is similar to the intensive cultivation in the neighbouring Punjab on account of access to irrigation. Diverse vegetables are being cultivated in the district since early 1970's for commercial sale. The area under cultivation of four vegetables (viz. cauliflower, cabbage, tomato and peas) selected for the study is given in Table 1.

Among these vegetable crops in Sri Ganganagar district, cauliflower occupied highest area followed by tomatoes and peas. Area under cabbage was low.

Pests and their management

Various pests and diseases were affecting these vegetable crops. Farmers reported that pest infestation was relatively higher in cole crops and tomato and was lower in peas. Farmers used all kinds of chemical pesticides as per package of practices. However, the use of non-chemical pest management options was limited.

Use of different pesticides

Use of different kinds of pesticides in the study area is given in Table 2. All the farmers in the study area used chemical insecticides for control of pests in all selected vegetable crops. The fungicides were used by 4 to 20 per cent farmers in different vegetables indicating that infestation of diseases was lower compared to insect pests. Biopesticides were used by <5% farmers. Botanical pesticides were used by <3% farmers cultivating cabbage and none of the farmers used them in other crops. The chemical insecticides were the most used pesticides on account of easy access and better efficacy. The chemical pesticides are easily available at agricultural input shops in each and every village whereas there is a lack of availability of range of biopesticides for different pests and diseases. Farmers have concerns on the use of biopesticides in commercial crops because of their efficiency and inconsistent results (Mawar et al., 2021).

Table 1. Area under cultivation of selected vegetables in Sri Ganganagar district of Rajasthan

Crops	Rajasthan		Sri Ganganagar		Share of Sri Ganganagar
	Area (ha)	Relative share (%)	Area (ha)	Relative share (%)	to Rajasthan in area (%)
Cauliflower	10644	25.52	330	53.75	3.10
Cabbage	1191	2.86	32	5.21	2.68
Tomato	18537	44.45	131	21.34	0.70
Peas	11331	27.17	121	19.71	1.06
Total	41703	100.00	614	100.00	1.47

Source: Krishi Vigyan Kendra, 2021; Agriculture Contingency Plan, 2021

Table 2. Use of different types of pesticides in vegetable cultivation by farmers (%)

Pesticide class	Cauliflower	Cabbage	Tomato	Peas	Total
Insecticides	100.00	100.00	100.00	100.00	100.00
Fungicides	20.00	9.52	6.00	4.00	20.00
Bio pesticides	4.00	4.76	0.00	2.00	2.00
Botanical pesticides	0.00	2.38	0.00	0.00	1.00

Trust for Advancement of Agricultural Sciences reported that the present pesticide use pattern in India is highest for insecticides followed by herbicides, fungicides + bactericides, other-pesticides, whereas the global pesticide use pattern was highest for herbicides followed by fungicides + bactericides, insecticides, other pesticides (TAAS, 2020). According to various studies, cotton is the most pesticide consuming agri-product (93.27%), followed by vegetables (87.2%), wheat (66.4%), millets (52.6%), and mustard (12.6%) (Maurya and Malik, 2016; Yadav and Dutta, 2019; Nayak et al., 2020).

Frequency and intensity of pesticide application

The frequency of pesticide spray in Sri Ganganagar district in the vegetable crops is provided in Table 3. The average number of chemical sprays ranged from 13-15 in each crop in a single crop cycle indicating that pesticides were sprayed at an interval of every 15 days. The total number of sprays by different farmers varied from minimum of 4 in cauliflower to as high as 22 in cabbages.

In cauliflower, about 60 per cent farmers had an average of 14 or less sprayings, while the remaining gave 14-17 sprayings. In cabbage, about 81 per cent farmers had on an average 15 or less sprayings, while the remaining applied 16 or more sprayings. In tomato, about 63 per cent farmers applied on an average 15 or less sprayings, while the remaining gave 16-19 sprayings. In peas, about 76 per cent farmers gave on an average 13 or less sprayings, while the remaining applied 13 or more sprayings.

In cauliflower, 44 per cent farmers applied 4 kg or less of technical grade pesticides per ha and the remaining 55 per cent used more than 4 kg of active ingredient (a.i)/ha. In cabbage, 71 per cent farmers applied 4 kg or less of a.i/ha and the remaining applied more than this quantity. In tomatoes, 38 per cent farmers applied 4 kg or less of a.i/ha and the remaining applied more than this quantity. In peas, 53 per cent farmers applied 4 kg or less of a.i/ha and the remaining applied more than this quantity (Table 4). The average use of chemical pesticides ranged from 5.16 kg a.i/ha in tomatoes to 3.47 kg a.i/ha in peas. There was a substantial variation among farmers ranging from 1 kg a.i/ha in cabbage to 6.48 kg a.i/ha in peas.

History of use of pesticides

Farmers were found using chemical pesticides since late 1960's and early 1970's. Upto 94 per cent farmers in Raisinghnagar block were using chemical pesticides for more than 20 years (as on agricultural year 2017-18) whereas only 59 per cent farmers in Ganganagar block fell in this category. Large farmers (with access to other resources as well) were found to have adopted the pesticides relatively earlier than the small farmers in both the blocks.

It was interesting to note that 60 per cent farmers had adopted IPM practices (atleast one practice other than the chemical pesticides for control of pests and diseases) in Ganganagar whereas only 38 per cent farmers did so in Raisinghnagar block. However, the adoption of IPM in totality was very low as evident from the number of sprays and quantity of chemical pesticides used (Tables 3 and 4). Study conducted in Banda district in Bundelkhand region of Uttar Pradesh reported that lack of knowledge of IPM technology, pesticides and their application pattern, bio-pesticides or other alternatives were the major constraints faced by vegetable growers in adoption of IPM technologies (Gupta et al., 2020).

In India, only 12 different kinds of biopesticides under the Insecticide Act of 1968 have been recorded (Kandpal, 2014), while the register for use as chemical pesticides is greater than 230 synthetics (Sharma et al., 2018). However, biopesticide use

Table 3. Distribution of farmers based on frequency of pesticide application*

Number of	Cauliflower		Cabbage		Tomato		Peas	
applications	% farmers	Cumulative %	% farmers	Cumulative %	% farmers	Cumulative %	% farmers	Cumulative %
<11	4	4	2.38	2.38	8.11	8.11	14.71	14.71
11	6	10	7.14	9.52	5.41	13.51	17.65	32.35
12	18	28	11.90	21.43	5.41	18.92	23.53	55.88
13	22	50	23.81	45.24	16.22	35.14	20.59	76.47
14	18	68	26.19	71.43	24.32	59.46	14.71	91.18
15	18	86	11.90	83.33	2.70	62.16	2.94	94.12
>15	14	100	16.67	100.00	37.84	100.00	5.88	100.00
Average	14		15		15		13	
Range	4-17		11-22		12-19		9-16	

*Insecticide applications included both spraying and dusting

Table 4. Distribution of farmers based on pesticide use intensity

Pesticide use intensity	Cauliflower		Cabbage		Tomato		Peas	
(kg a.i./ha)	% farmers	Cumulative %	% farmers	Cumulative %	% farmers	Cumulative %	% farmer	Cumulative %
<2	6	6	16.67	16.67	5.41	5.41	2.94	2.94
2-3	10	16	23.81	40.48	8.11	13.51	29.41	32.35
3-4	28	44	30.95	71.43	24.32	37.84	20.59	52.94
4-5	22	66	7.14	78.57	29.73	67.57	26.47	79.41
5-6	16	82	2.38	80.95	18.92	86.49	11.76	91.18
>6	18	100	19.05	100.00	13.51	100.00	8.82	100.00
Average (kg a.i./ha)	4.23		3.87		5.16		3.47	
Range	1.07-6.22		1.00-6.08		1.33-6.76		1.03-6.48	

Table 5. Experience (years) of spraying pesticides and adoption of IPM

Experience (years)	Ganganagar			Raisinghnagar		
	Small	Large	All	Small	Large	All
10-15	1.00	0.00	1.00	0.00	0.00	0.00
15-20	21.00	60.00	40.05	12.00	0.00	6.00
20-25	53.00	20.00	36.50	50.00	50.00	50.00
25-30	25.00	20.00	22.45	38.00	50.00	44.00
Adoption of IPM						
Yes	20.00	100.00	60.00	11.00	65.00	38.00
No	80.00	0.00	40.00	89.00	35.00	62.00

expanded significantly from 123 metric tonnes (MT) in 1994–1995 to 8110 MT in 2011-2012 (Mishra et al., 2020). According to Directorate of Plant Protection, Quarantine and Storage data, the overall consumption of biopesticides in India has increased from 7190 MT in 2014-2015 to 8645 MT in 2018-2019 (MoA, 2021b). There are currently 970 biopesticide products registered with the Central Insecticides Board and Registration Committee (CIBRC) (MoA, 2021c).

Farmers' perception about the effect of prolonged use of pesticides

Exposure to pesticides over a long period of time may lead to adverse effect on health. Around 85 per cent farmers in Ganganagar and 68.5 per cent farmers in Raisinghnagar were aware that prolonged use of pesticides can affect health adversely. Further, 70 per cent farmers in Ganganagar reported that prolonged use of pesticides can lead to very high and extremely high risks such as chronic diseases (Table 6). The high risk groups exposed to pesticides include production workers, formulators, sprayers, mixers, loaders and agricultural farm workers (Aktar et al., 2009). Study in Tamilnadu reported that 37.3 per cent farmers were involved in other farming activities on the farms while pesticides were being sprayed. During the spraying operation, non-sprayers (40.1%), including women (19.3 per cent), continued to work in the same field, which exposed them to pesticides (Chitra et al., 2006). Only around 0.1 per cent of pesticides are believed to reach the intended organisms, with the rest polluting the environment and causing environmental harm (Carriger et al., 2006; Gill and Garg, 2014).

Monetary valuation of the adverse effects of pesticides on human health

It was found that a person engaged in pesticide spray lost 8 days in one season in Ganganagar and 7 days in Raisingh Nagar (Table 7). Total monetary loss including days lost, loss in work efficiency in the event of not taking medicines and value of medical kit was Rs. 18143.10 in Ganganagar and Rs. 3553.83 in Raisinghnagar. Monetary loss was more on large farms in Ganganagar and small farms in Raisinghnagar. The cost per hectare on account of adverse effect on health amounted to Rs. 6760 in Ganganagar and Rs. 12887 was in Raisinghnagar. Farmers need to be protected for sub-standard products and programs for safe use

Table 6. Farmers' perception about the effect of prolonged use of pesticides

Particulars	Ganganagar			Raisinghnagar		
	Small	Large	All	Small	Large	All
Yes	90.00	100.00	85.00	71.00	66.00	69.00
No	11.00	0.00	5.50	28.00	33.00	30.50
Degree of effects						
Very little	6.00	0.00	3.00	12.00	0.00	6.00
High	22.00	20.00	21.00	75.00	15.00	45.00
Very high	72.00	60.00	66.00	14.00	76.00	45.00
Extremely high	0.00	20.00	10.00	0.00	6.00	3.00

Table 7. Monetary valuation of the adverse effects of pesticides on human health (persons/households)

Particular	Ganganagar			Raisinghnagar		
	Small	Large	All	Small	Large	All
Mandays lost (Days/Person)	8	9	8	10	6	7
Loss in monetary terms (Rs/person) (@ Rs. 300/manday)	2400	2700	2540.10	3000	1800	1900
Loss in work efficiency because of not taking medicines (Rs/person)	210	316	250	157	210	180.33
Cost of medical kit (Rs/person)	8	3	5	12	30	21
Medical expenditure (Rs/person)	2340	28340	15340	1122	1768	1445.50
Total	4966	31368	18143.10	4301	3814	3553.83
Area for spray (ha)	1.02	2.356	1.543	0.98	2.034	1.125
Rs./ha	2220	11300	6760	8344	17430	12837

of pesticides and reduction of potential health and environmental impacts should be undertaken. Possibility of sub-standard products cannot be ruled out and therefore, enforcement of point-of sale quality inspection and protection of farmers with consumer forums deserve emphasis (Subash et al., 2017).

It was evident that the use of chemical pesticides was very high in vegetable crops in the study region. Network of agricultural input dealers and retailers were used by the private companies to promote their inputs including pesticides. Paying a handsome commission to agriculture input dealers ranging from 15-20 per cent of the sale price to push their products was one of their most successful marketing strategies (Manjunatha et al., 2015; Manjunatha et al., 2018). Study conducted in Ludhiana district of Punjab revealed that in case of rice crop, 77 per cent farmers purchased pesticides from private dealers, 20 per cent from cooperative societies and only 3% purchased from government agencies such as agricultural department and IFFCO. Further, none of the farmers practised biological insect control methods (Sharma et al., 2020).

The economic part in vegetable crops is edible unlike in cotton where economic part is non-edible. IPM and Non Pesticidal Management (NPM) practices need to be promoted by all the stakeholders wherein chemical pesticides should remain as the last option. The awareness among farmers and consumers on safe food has increased. The need for paradigm shift from chemical inputs based agriculture to sustainable models has been acknowledged across the globe. India is promoting organic and natural farming through schemes like Paramparagat Krishi Vikas Yojana (PKVY), National Project on Organic Farming and Organic Value Chain Development for North East Region. Successful implementation of these schemes calls for sufficient budget allocation and reorientation of whole extension system to educate and facilitate the farmers towards sustainable environment friendly technologies and practices.

CONCLUSION

The study highlighted various aspects of pesticide use in vegetable cultivation. Use of chemical pesticides was the predominant pest control method practised by the farmers. Bio pesticides and botanical pesticides were used by a very limited number of growers in limited crops. Farmers were aware of IPM practices for pest control however, its adoption was limited. The primary motive of commercial vegetable cultivators was to control pests (in turn increase production). In the process, health of farmers/ farm workers themselves and consumers was jeopardized. Economic impact of overuse and misuse of chemical pesticides on biodiversity, natural resources and ecosystem as a whole needs to be assessed holistically to derive the breakeven point at the farmer, community and the society level.

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