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Research Article

PLANT PROTECTION CHEMICALS' USE BEHAVIOUR OF CAULIFLOWER GROWERS IN CONTROLLING INSECT-PESTS AND DISEASES

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A B S T R A C T

India is an agriculture based country. Imbalance between demand and supply of agricultural production is a major concern to feed the ever-increasing population of our country. To enhance agricultural production, there are several ways. Out of various ways, plant protection occupies prime position. Insect-pests and diseases cause enormous damage to agricultural crops, forests as well as stored agricultural commodities. Almost every economically important plant is attacked by a variety of insect-pests and diseases. Therefore, the study was concentrated on the objective- to portray the plant protection chemicals use bavaviour in cauliflower cultivation in controlling insect-pests and diseases. The study was conducted in Hooghly district of West Bengal. For the selection of area and respondents of the present study, multi-stage random sampling technique and universe method were followed. The study reveals that (1) at the most 38 percent of respondents had primary level of education (2) at the most 31 percent of respondents had 1.1 to 2.0 bigha of own cultivable land (3) at the most 30 percent of respondents had 5.1 to 10 kathas (20 katha=1 bigha, 3 bihga= 1 acre, 2.5 acre=1 ha=7.5 bigha=150 katha) of land for vegetable cultivation (4) at the most 35 percent of respondents had 11-20 years of experience in vegetable cultivation (5) at the most 33 percent of respondents had upto 11-20 years of experience in cauliflower cultivation (6) at the most 40 percent of respondents had 11-20 years of experience in plant protection chemicals' application (7) All the respondents (100%) cultivated cauliflower crop in rabi season mainly (8) majority of the respondents (60%) applied plant protection chemicals' on 4-7 days interval (9) all the respondents (100%) adopted spraying method for application of plant protection chemicals (10) all the respondents' (100%) main personal source of information on plant protection chemicals' use was agricultural input retailers (11) nearly half of respondents (46%) main impersonal source of information on plant protection chemicals' use was radio (12) At the most 70 percent of respondents used 30-40 litres of water per bigha for spraying chemicals at seedling stage (13) at the most 61 percent of respondents used 40-80 litres of water per bigha for spraying chemicals at mature stage of the crop (14) at the most 15 percent of respondents used phorate 10G for soil treatment (15) at the most 26 percent of respondents used Mancozeb (Dithane M-45) for seed treatment (16) all the respondents (100%) reported that insect-pests and diseases mainly infested the crop at mature stage (17) according to the report of cauliflower growers (100%), diamond back moth was the most harmful insect-pest of cauliflower crop (18) majority of respondents (51%) reported, downy mildew disease was the most harmful disease of cauliflower crop (19) to control the insect-pests and diseases, respondents used various plant protection chemicals with their various brands and in various doses (20) generally, farmers used more amount of chemicals than the recommended amount (dose) for controlling insect-pests and diseases (21) the study also indicated that nowadays the mixed agro-chemicals are coming in market for controlling insect-pests and diseases. (22) the study also revealed that farmers are not following various precautions properly in applying plant protection chemicals. Therefore, the various public extension agencies, pesticide companies and non-government organizations should re-orient their extension programmes on the basis of the findings of the present investigation.

INTRODUCTION

The rapid and continuing increase in population implies a greater demand for food and nutrition. The growth rate of food grain production decelerated to 1.2 percent during 1990-2007, lower than the population growth of 1.9 percent. The contribution of agriculture and allied sector has fallen from 61 to 17.5 percent, in the last few years. Marked deceleration in agricultural growth is certainly a cause of serious concern. With per annum population growth still over 2.1 percent, it will touch 1.4 billion by 2030 and 1.7 billion by 2050 AD, needing annually about 380 million tonnes and 480 million tonnes food grain which account about 52.6 percent and 92.7 percent increase in food production respectively. Hence the task of providing food and nutrition to our vast population poses to be really daunting. Sustainable food and nutrition security involves meeting current needs in agricultural

production without sacrificing the prospects for meeting the needs of future generation. Taking note of a sluggish, almost stagnant agricultural growth in the recent years, acting as a drag of country's economic growth, it is imperative to make all round development in agriculture to achieve a turnaround in agricultural production and growth and to make that happen agricultural scientists of the country have to play important roles (Sarkar, 2015). India has moved from scarcity and technological fatigue to technological resurgence and self-reliance in food through the route of intensive agriculture by use of chemical fertilizers and pesticides apart from the genes that provided the green revolution. While reaping benefits of the chemicalisation, India is witnessing signs of its ill-effects that are severely threatening sustainability and safety for food and environment**.** Thus, to enable trigger hope among growers, there is need to make farming attractive through improvements in sustainability indices so that while maximizing profits, we do not lose our sight of minimizing risks, safeguarding whatsoever is produced (Chattopadhyay, 2015). Though agriculture continues to be the prime mover of Indian economy, we are living in such times where the lands under agriculture either get diverted or get shrunk every other day. Besides, more and more people are leaving agriculture in search of greener pastures. It is high time for us to understand that the saga and the success that we reaped in green revolution are long over. We need to come up with brand new techniques, technologies and approaches to make farming viable; uplift farms, farmers and their resources; and to resuscitate the overall notion of rural development in general (Pathak , 2016). Sustainability means meeting needs without compromising future generations and thus in sustainable agriculture there is a commitment to satisfy human food, fuel, timber and fibre needs and to enhance the quality of life for farmers and society as a whole, now and into the future. With the introduction of modern agricultural technologies, India has moved from an era of chronic food shortages and 'begging bowl' status upto 1960s to food self sufficiency and even food exports. However, Indian agriculture has lost its dynamism in the recent years.

The rapid and continuing increase in population implies a greater demand for food and nutrition (Sengupta, 2015). The pollution of environment, loss of biodiversity, toxic residue in food, development of pest resurgence, outbreak, hazardous to consumers and elimination of natural enemies from crop ecosystem have well illustration in the recent years. This is the fact that 1% of pesticides are reaching to the target pest and rest of 99% is reaching to the non-target sectors (Kumar et al. 2015). Maintaining the productivity level in a sustainable manner considering ecological balance with sound resource management would be key issue in the coming decades (Aswal and Sha, 2011). Among the crops, it is observed that vegetable cultivation is input intensive and care intensive cultivation. Vegetables are the one of the major users of plant protection chemicals. Vegetable growers' plant protection chemicals' use behaviour is dynamic in nature which requires regular research to know their existing use pattern and their future expectations on the basis of their felt problems. Therefore, collection of reliable information and knowledge about plant protection chemicals' use pattern of the vegetable growers becomes crucial for wide range of stakeholders. Considering the importance of the study, the objective –to portray the plant protection chemicals' use behaviour of cauliflower growers in controlling insect-pests and diseases was undertaken.

METHODOLOGY

The study was undertaken in the state of West Bengal. For the selection of area and respondents of the present study, multi-stage random sampling technique and universe method were adopted. At the first stage of sampling, Hooghly district was selected among the 19 agricultural districts of the state purposely based on its' comparatively higher area coverage in cauliflower cultivation. Out of 16 blocks of Hooghly district, one block (i.e. Singur) was randomly selected at the second stage of sampling. In the selected block (Singur) a relatively homogeneous field cultivated with vegetable crops was chosen on the basis of the opinion of the agricultural input retailers. The farmers who were growing cauliflower in that field were selected as respondents of the study through total enumeration. Thus total 100 hundred farmers ultimately considered as respondents of the present investigation. Personal interview method was adopted to collect data by using local language (Bengali) for getting their response exactly. Statistically, simple percentage method was used for analysis of data to reach at meaningful results and conclusion.

RESULTS AND DISCUSSION

The data collection was done in Hooghly district of West Bengal. The district is famous for potato cultivation. Other main crops except potato were rice, banana and vegetables. Among the vegetable crops most identifiable ones were tomato, cauliflower, ladies finger and brinjal. The study area covered the villages of Nasibpur, Dashi, Sundarpur, Bhanderda, Jaminberia, Ratanpur, Mallikpur, Berh, Purusottampur and Rasulpur.

Level of education (table-1):- The study revealed that at the most 38 percent of respondents had upto primary level of education and at the lowest 8 percent of respondents had graduate and above level of education. Other levels of education were illiterate (13%), secondary level (30%) and higher secondary level (11%).

Table-1 Level of education (N=100)

Level of education	No. of respondents possessed	Percentage of respondents possessed
Illiterate	13	13
Primary level	38	38
Secondary Level	30	30
Higher secondary level	11	11
Graduate level and above	8	8

Own cultivable land (table-2):- The table indicates that at the most 31 percent of respondents had 1.1-2.0 bigha of own cultivable land whereas at the lowest 10 percent of respondents had more than 6 bigha of own cultivable land. Other respondents came under categories of– upto 1 bigha (23%), 2.1-4.0 bihga (24%) and 4.1-6.0 bigha (12%).

Table-2 Own cultivable land (N=100)

Land possessed (bigha)	Number of respondents	Percentage of respondents
Upto 1	23	23
1.1-2.0	31	31
2.1-4.0	24	24
4.1-6.0	12	12
Above 6.0	10	10

Vegetable cultivable land (table-3):- The table indicates that at the most 30 percent of respondents had 5.1 to 10 katha of land for vegetable cultivation whereas at the lowest 3 percent of respondents had above 4 bigha of land under vegetable cultivation. Other categories were- Upto 5 katha (22%), 10.1 to 20 katha (28%), 1.1 to 2 bigha (9%) and 2.1 to 4 bigha (8%). The finding reveals that day by day per capita land holding of farmers is decreasing due to pressure of population.

Table-3 Vegetable cultivable land (N=100)

Land possessed	Number of respondents	Percentage of respondents
Upto 5 katha	22	22
5.1-10 katha	30	30
10.1 to 20 katha	28	28
1.1 to 2 bigha	9	9
2.1 to 4 bigha	8	8
Above 4 bigha	3	3

Number of years cultivating vegetables (table-4) :- The table expressed that at the most 35 percent of respondents had 11-20 years of experience in vegetable cultivation whereas at the lowest 9 percent of respondents had above 40 years of experience in vegetable cultivation. Other categories were- upto 10 years (23%), 21-30 years (18%) and 31-40 years (15%).

Table-4 Number of years cultivating vegetables (N=100)

Number of years cultivating vegetables	Number of respondents	Percentage of respondents
Upto 10	23	23
11-20	35	35
21-30	18	18
31-40	15	15
Above 40	9	9

Number of years cultivating cauliflower (table-5):- The table indicates that at the most 33 percent of respondents had upto 11-20 years of experience in cauliflower cultivation whereas at the lowest 9 percent of respondents had above 40 years of experience in cauliflower cultivation. Other categories were – upto 10 years (32%), 21-30 years (14%) and 31-40 years (12%).

Table-5 Number of years cultivating cauliflower (N=100)

Number of years cultivating cauliflower	Number of respondents	Percentage of respondents
Upto 10	32	32
11-20	33	33
21-30	14	14
31-40	12	12
Above 40	9	9

Number of years applying plant protection chemicals (Table-6):- The table indicates that at the most 40 percent of respondents had 11-20 years of experience in plant protection chemicals application and at the lowest 14 percent of respondents had above 30 years of experience in plant protection chemicals application. Other categories were upto10 years (26%) and 21-30 years (20%). It is clear from the study that last 20 years, plant protection chemicals use has increased upto a great extent (66%).

Table-6 Number of years applying plant protection chemicals (N=100)

Number of years applying plant protection chemicals	Number of respondents	Percentage of respondents
Upto 10 years	26	26
11-20 years	40	40
21-30 years	20	20
Above 30 years	14	14

Season (table-7):- At the most 12 percent of respondents cultivated the crop in kharif season whereas 100 percent of them preferred to cultivate it in rabi season and in pre-kharif (summer) season no one cultivated the crop. It is clear from the study that cauliflower is not a round the year crop and have market demand only in seasonal basis.

Table-7 Season (N=100)

Season	Number of respondent cultivated	Percentage of respondent cultivated
Kharif	12	12
Rabi	100	100
Summer	0	0

Interval of applying plant protection chemicals (table-8):- Respondents in the study area preferred to apply plant protection chemicals in the following days' interval-1 days (2%), 2-3 days (13%), 4-7 days (60%), 8-15 days (13%) and more than 15 days (12%).

Table-8 Interval of applying plant protection chemicals (N=100)

Days interval	Number of respondent applied	Percentage of respondent applied
1	2	2
2-3	13	13
4-7	60	60
8-15	13	13
More than 15	12	12

Methods of application plant protection chemicals (table-9): -All the respondents in the study area (100%) applied plant protection chemicals mainly through spraying whereas 26 percent of cauliflower growers followed dibbling method (digged the soil and the plant protection chemicals were inserted and filled the hole by soil again especially application of granular plant protection chemicals) and only 15 percent of selected farmers also applied the chemicals by following dusting method.

Table-9 Method of application of plant protection chemicals (N=100)

Method	Number of respondent applied	Percentage of respondent applied
Spraying	100	100
Dibbling	26	26
Dusting	15	15

Personal source of information in using plant protection chemicals (table-10): - At the most cent percent of respondents' (100%) main source of information in using plant protection chemicals was agricultural input retailers who provided information mainly at the time of purchasing whereas at the lowest 4 percent of respondents collected information from experts of agricultural university when they participated any training programme at university or

personally. Other categories in this regard are the followings:- Fellow farmers (78%), Neighbours (33%), Big farmers (52%), Relatives (21%), ADOs & KPS (10%), Company personnel (20%) and Agricultural fair (8%). After collecting the information from various sources, each respondent evaluated it in their level best and finally applied the suitable one. Singh et al. (2014) reported that about one-third of the respondents (33.75%) and nearly one-fourth of the respondents (23.75%) had medium and high overall information seeking behaviour respectively. Private dealers, friends, kisan mela and PAU scientists were emerged as the main sources of seeking information. The weed control, plant protection, recommended varieties and fertilizer applications were the major areas for seeking information regarding vegetable cultivation. Most of the respondents shared information with neighbours, friends, relatives and mode of sharing was verbal as stated by 100 percent of the respondents. Nidhi et al. (2016) indicated that 63.37 percent of farmers were having very good knowledge about several IPM practices. Among these practices 71.37 percent farmers had very high knowledge with regards to cultural practices for pest management in cauliflower cultivation and only 26.60 percent of farmers had knowledge about bio-control practices. It indicates that farmers had very poor knowledge about bio-control practices under IPM in cauliflower cultivation.

Table-10 Personal sources of information on plant protection chemicals' use (N=100)

Personal source	No. of respondents collected	Percentage of respondents collected
Agricultural input retailers	100	100
Fellow farmers	78	78
Neighbours	33	33
Big farmers	52	52
Relatives	21	21
ADOs and KPSs	10	10
Experts of Agril. University	4	4
Company personnel	20	20
Agricultural Fair	8	8

(ADO=Agricultural Development Officer; KPS=Krishi Prayukti Sahayak)

Impersonal sources of information on plant protection chemicals use (table-11):- Still, radio is playing an important role in disseminating agricultural technologies to farming communities. It is a very convenience mass media to access information compare to other impersonal media and it was reported by 46 percent of respondents. At the lowest 2 percent of respondents told they collected information from magzine. Other impersonal sources were- T.V. (15%), Newspaper (7%), book (4%), internet (8%) and kisan call centre (4%).

Table-11 Impersonal sources of information on plant protection chemicals use (N=100)

Impersonal source	No. of respondents collected	Percentage of respondents collected
Radio	46	46
T.V.	15	15
Newspaper	7	7
Book	4	4
Magazine	2	2
Internet	8	8
Kisan call centre	4	4

Amount of water used for spraying plant protection chemicals (table-12):- For application of plant protection chemicals, per bigha water requirement was 30 to 40 litre at seedling stage and it was followed by majority of respondents (70%). At mature stage, water requirement for spraying was 40-80 litre per bigha and it was followed by majority of the respondents (61%).

Table-12 Amount of water used for spraying plant protection chemicals (N=100)

Crop stage	Amount of water required for spraying (per bigha)	Number of respondent followed	PRF
Seedling stage	30-40	70	70
Mature stage	40-80	61	61

(PRF= Percentage of respondent followed)

Soil treatment (table-13):- There are many soil borne inset-pests and diseases those infest the crop. To prevent that incidence, the respondents of the study area applied various plant protection chemicals. They generally applied two chemical mainly these are –Phorate 10G (15 percent of respondents applied @ 1-3 kg per bigha) and Carbafuran 3G (12 percent of respondents applied @ 2-5 kg per bigha).

Table-13 Soil treatment (N=100)

Name of agro-chemicals	Commercial name	Recommended dose (per bigha)	Applied dose (per bigha)	No. of respondents applied	Percentage of respondents applied
Phorate 10G	Thimet	1.5 kg	1-3 kg	15	15
Carbafuran 3G	Furadon	4 kg	2-5 kg	12	12

Seed treatment (table-14):- Seed treatment refers to the application of fungicides, insecticides, or a combination of both, to seeds so as to disinfect and disinfect them from seed borne pathogenic organisms and storage insects. Many diseases can be controlled by a simple chemical seed treatment. Plant disease organisms survive from season to season through spores carried on or in seeds. The young seedling is protected from attack until it is capable of outgrowing attacks from soil borne pathogens. Some chemical seed treatments provide a protective zone around the seed through which soil-borne organisms cannot penetrate. It was seen that in study area 26 percent of respondents used Mancozeb @2.5-5 gm/kg of seed for seed treatment and only 17 of respondents used Carbendazim @3-5 gm/kg of seed for seed treatment. Cauliflower growers also reported information that nowadays purchased seeds are already treated by companies or sellers; therefore, there is no need to treat those seeds again.

Table-14 Chemicals used for seed treatment (N=100)

Name of plant protection chemicals	Commercial name	Recommended dose (per kg seed)	Applied dose (per kg seed)	No. of respondents applied	Percentage of respondents applied
Mancozeb 75% WP	Dithane M-45	3 gm	2.5-5 gm	26	26
Carbendazim 50% WP	Bavistin	2 gm	3-5 gm	17	17

Insect-pests of cauliflower (table-15):- Various insect-pests of cauliflower as reported by respondents are given below in the following table:-

Table-15 Various insect-pests of cauliflower (N=100)

Insect-pests of cauliflower	Number of respondents reported	Percentage of respondents reported
Diamond back moth	100	100
Tobacco caterpillar	30	30
Cabbage butterfly	50	50
Cabbage borer	24	24
Cabbage aphid	47	47
White fly	38	38

Soni et al. (2013) reported that the cauliflower growers had lower level of adoption on the following aspects; weed management (38.75%), seed treatment (29.38%), disease management (25.00%) and for insect-pest management (7.50%). Chaturvedi et al. (2010) concluded that knowledge gap among the respondents of periphery category were- seed treatment (46.67%), weed management (30.00%), plant protection (33.34%) whereas knowledge gap among the respondents of distant category were- seed treatment (60%), weed management (43.34%) and plant protection measures (53.34%). Jakhar (2014) cauliflower is severely damaged by multiple insect-pests complex and constitutes one of the major limiting factors in crop production. The main insects are diamond back moth (*Plutella xylostella*), head caterpillar (*Crocidolomia binotalis*), *Spodotera lutera* and Heliothis (*Helicoverpa armigera*) in India. The yield loss caused by diamond back moth varies from 31 to 100 percent.

Plant protection chemicals used to control diamond back moth (table-16):-

Diamond back moth (*Plutella xylostella***)**: - This is a serious pest of cauliflower. The tiny caterpillars bite holes by feeding on the leaves giving a short –hole effect all over the leaves. In dry season they become abundant enough to cause appreciable damage. The moth is greyish brown with narrow wings and pale white markings along the back of the forewings which form a diamond shaped pattern when folded. The hind wings have a fringe of long hairs.The caterpillars are small, slender, pale-green in colour with short thin hairs on the body. The plant protection chemicals used, dose applied and percentage of respondents adopted are the followings (table-16):- Cypermethrin 25%EC @ 1-3ml/litre of water (35%), Cypermethrin 10 %EC@ 1-3ml/litre of water (31%), Phosphamidon 40%EC@ 1-2ml/litre of water (16%), Quinalphos 25%EC@ 2-3ml/litre of water (7%), Methyl Parathion 50%EC@ 1ml/litre of water (5%), Chlorpyriphos 20%EC @ 2-3ml/litre of water (6%) and Fipronil 5% EC@ 1-2ml/litre of water (3%). It is seen from the table that farmers are using lot of chemicals to control a insect-pest, but, practically one application of a particular chemical is effective for controlling other insect-pests also. Therefore, farmers are using limited number of chemicals. Lad and Peshkar (2016) reported that recommended insecticide Quinalphos 0.05% offered maximum per cent mean reduction in the larval population to the extent of 73.79 per cent followed by *Trichogrammatoidea bactrae* @1.5 lakh eggs /ha, *Bacillus thuringiensis* @1000ml/ha, *T. chilonis* @ 1.5 lakh eggs /ha, registering percent mean larval population reduction to the tune of 52.19, 50.41and 45.22 respectively. It is concluded that Quinalphos 0.05% still effective as recommended for the management of Diamond back moth. Senguttuvan et al. (2014) revealed that Lufenuron 5.4 EC, Indoxacarb 15.8 EC and Cartap Hydrochloride 50 SP. were effective in reducing diamond back moth population in cauliflower. Lufenuron 5.4 EC at 60g a.i. /ha showed highest mortality in first (80.83%) and second (75.07%) season trials against the pest. Lufenuron 5.4 EC at all the doses was comparatively less toxic to *Cotesia* (21.27-33.17%) in first and (23.90-47.28%) in second season trials on cauliflower, when compared to standard check indoxacarb. Cartaf hydrochloride was more toxic *Cotesia* by recording a cumulative mean per cent reduction of 50.78, 46.87 at first and 61.49, 64.81 at second season trials respectively.

Table-16 Plant protection chemicals used to control diamond back moth (N=100)

Brand Name	Plant protection chemicals	Recommended dose per litre of water	Number of respondents adopted	Percentage of respondents adopted	Dose applied (per litre of water)
Ripcord	Cypermethrine 25%EC	0.5ml	35	35	1-3ml
Superkiller	Cypermethrin 10 %EC	1ml	31	31	1-3ml
Sumidon	Phosphamidon 40%EC	1.5ml	16	16	1-2ml
Ekalux	Quinalphos 25%EC	2.0ml	7	7	2-3ml
Metacid	Methyl Parathion 50%EC	1ml	5	5	1ml
Dursban	Chlorpyriphos 20%EC	2.5ml	6	6	2-3ml
Regent	Fipronil 5% EC	1ml/litre	3	3	1-2ml/litre

Plant protection chemicals used to control tobacco caterpillar (table-17):-

Tobacco caterpillar (*Spodoptera litura***):-** The caterpillars feed voraciously on the leaves, shoots and fruits at night and become isolated at the later stage of the growth. The pest is confined to nursery beds and is also classed as cutworm. The moth is greyish brown with white markings on the forewings and hind wings with irradiantly white with a brown border. The thorax and abdomen are light brown and display a tuft of hairs in the end. The plant protection chemicals used, dose applied and percentage of respondents adopted are the followings (table-17):- Cypermethrine 25%EC @ 1-3ml/litre of water (30%), Endosulfon 35%EC @ 1-3ml/litre of water (21%), Dichlorvos 76% E.C.@ 1.5-3ml/litre of water (19%), Cypermethrine 10% EC @ 1-2ml/litre of water (9%) and Cypermethrine 25% EC @ 0.5-1ml/litre of water (11%).

Table-17 Plant protection chemicals used to control tobacco caterpillar (N=100)

Brand Name	Plant protection chemicals	Recommended dose per litre of water	Number of respondents adopted	Percentage of respondents adopted	Dose(per litre of water)
Ripcord	Cypermethrine 25%EC	0.5ml	30	30	1-3ml
Thiodan	Endosulfon 35%EC	2ml	21	21	1-3ml
Nuvan	Dichlorvos 76% E.C.	0.75ml	19	19	1.5-3ml
Cymbush	Cypermethrine 10% EC	1ml	9	9	1-2ml
Cilcord	Cypermethrine 25% EC	0.5ml	11	11	0.5-1ml

Plant protection chemicals used to control cabbage butterfly (table-18)

Cabbage butterfly (*Pieris brassicae***)**: - The caterpillars feed voraciously on the leaves, shoots and pods and when they are grown up, they disperse themselves to various parts of the plants. They start feeding from the margin of leaf and proceed to the centre. The whole leaf and plant may be stripped

resulting in poor yield and quality of produce. The butterfly is large, yellowish white insect with a pair of black dots on each forewing. The caterpillars are tiny with body covered with short hairs. The plant protection chemicals used, dose applied and percentage of respondents adopted are the followings (table-18):- Cypermethrine 10%EC @ 1-2ml/litre of water (16%), Cypermethrine 25%EC @0.5- 1ml/litre of water (12%), Cypermethrine 25%EC @0.5- 1ml/litre of water (32%), Endosulfon 35%EC@ 1-3ml/litre of water (9%), Methyl Parathion 50%EC @ 1ml/litre of water (10%) and Phosphamidon 40%EC@ 1-2ml/litre of water (21%).

Table-18 Plant protection chemicals used to control cabbage butterfly (N=100)

Brand Name	Plant protection chemicals	Recommended dose per litre of water	Number of respondents adopted	Percentage of respondents adopted	Applied dose(per litre of water)
Ostaad	Cypermethrine 10%EC	1ml	16	16	1-2ml
Basathrin	Cypermethrine 25%EC	0.5ml	12	12	0.5-1ml
Ripcord	Cypermethrine 25%EC	0.5ml	32	32	0.5-1ml
Thiodan	Endosulfon 35%EC	2ml	09	09	1-3ml
Metacid	Methyl Parathion 50%EC	1ml	10	10	1ml
Sumidon	Phosphamidon 40%EC	1.5ml	21	21	1-2ml

Plant protection chemicals used to control cabbage borer (table-19)

Cabbage borer (*Hellula undalis***):-** The caterpillars bore into the stem, stalks or leaf veins and cause damage by making the produce unfit for marketing. The caterpillars pupate into the burrows or leaf folds or in the soil. The moths are pale – yellowish brown with wavy lines and a central elliptical grey marking on the forewings. The caterpillars are pale whitish brown with black head and four longitudinal lines on the body. The plant protection chemicals used, dose applied and percentage of respondents adopted are the followings (table-19):- Carbaryl 50%WP @ 2-3gm /litre of water (17%), Malathion 50%EC @2-3ml /litre of water (12%), Quinalphos 25%EC @2-3ml /litre of water (8%), Endosulfon 35%EC @ 2-3ml /litre of water (11%), Chlorpyriphos 20%EC @ 2-3ml /litre of water (13%) and Cypermethrine10%EC @ 1-2ml/litre of water (19%).

Table-19 Plant protection chemicals used to control cabbage borer (N=100)

Brand Name	Plant protection chemicals	Recommended dose	Number of respondents adopted	Percentage of respondents adopted	Dose (per litre of water)
Sevin	Carbaryl 50%WP	2.5gm	17	17	2-3gm
Cythion	Malathion 50%EC	2ml	12	12	2-3ml
Ekalux	Quinalphos 25%EC	2ml	8	8	2-3ml
Thiodan	Endosulfon 35%EC	2ml	11	11	2-3ml
Pyriban	Chlorpyriphos 20%EC	2.5ml	13	13	2-3ml
Sakti	Cypermethrine10%EC	1ml	19	19	1-2ml

Plant protection chemicals used to control cabbage aphid (table-20)

Cabbage Aphid *(Lipaphis erysimi)* **: -** Both the nymphs and adults suck the sap from the tender part of the plants. In cauliflower all the inner space in the head are filled by the aphids, thus making the vegetables unmarketable. The aphids excrete honey dew on which shooty mould grows covering the dorsal leaf surface. The aphids are small, yellowish green and soft insects and usually 2.5 to 3 mm long. The plant protection chemicals used, dose applied and percentage of respondents adopted are the followings (table-20) :- Malathion 50% EC @ 1.5 ml /litre of water (13%), Dimethoate 30%EC @2-3 ml /litre of water (32%), Quinalphos 25%EC @2-3ml /litre of water (10%), Chlorpyriphos 20% EC@ 2-3ml /litre of water (15%) and Monocrotophos 36%EC @ 1-3ml /litre of water (6%).

Table-20 Plant protection chemicals used to control cabbage aphid (N=100)

Brand Name	Plant protection chemicals	Recommended dose	Number of respondents adopted	Percentage of respondents adopted	Applied dose (per litre of water)
Malathion	Malathion 50% EC	2ml	13	13	1.5 ml
Rogor	Dimethoate 30%EC	2ml	32	32	2-3 ml
Ekalux	Quinalphos 25%EC	2ml	10	10	2-3ml
Dursban	Chlorpyriphos 20% EC	2.5ml	15	15	2-3ml
Suphos	Monocrotophos 36%EC	1.5ml	6	6	1-3ml

Plant protection chemicals used to control white fly (table-21)

White fly (*Aleyrodes proletella***): -** This is a minute pest. The larvae (scales) feed on the underside of the leaves and cause white or yellow patches. On the honey dew secreted by the pest, black mouldy growth develops. The plant protection chemicals used, dose applied and percentage of respondents adopted are the followings (table-21) :- Quinalphos 25%EC @ 2-3ml /litre of water (17%), Methyl Parathion 50%EC @1ml /litre of water (21%), Chlorpyriphos 20% EC @2-3ml /litre of water (19%), Cypermethrine 25%EC 0.5-1ml /litre of water (25%) and Phosphamidon 40%EC @ 1-2ml /litre of water (8%).

Table-21 Plant protection chemicals used to control white fly (N=100)

Brand Name	Plant protection chemicals	Recommended dose per litre of water	Number of respondents adopted	Percentage of respondents adopted	Dose (per litre of water)
Ekalux	Quinalphos 25%EC	2ml	17	17	2-3ml
Metacid	Methyl Parathion 50%EC	1ml	21	21	1ml
Dursban	Chlorpyriphos 20% EC	2.5ml	19	19	2-3ml
Cilcord	Cypermethrine 25%EC	0.5ml	25	25	0.5-1ml
Sumidon	Phosphamidon 40%EC	1.5ml	8	8	1-2ml

Diseases of cauliflower (table-22)

Table-22 Diseases of cauliflower (N=100)

Diseases of cauliflower	Number of respondents reported	Percentage of respondents reported
Downy mildew	51	51
Black spot or dark leaf spot	33	33
Ring spot	19	19
Watery soft rot or stalk rot	17	17
Browning or brown rot or red rot	22	22
Whiptail	6	6

More than half of respondents (51%) reported about the downy mildew disease of cauliflower, 33 percent reported about black spot disease, 19 percent of respondents reported about ring spot, 17 percent of respondents reported about watery soft rot or stalk rot disease, 22 percent of respondents reported about browning disease and at the lowest 6 percent of respondents reported about the whip tail disease of cauliflower. Kumar et al. (2016) reported that vegetables are more prone to diseases infection, thereby causing high yield losses. The use of resistant genotypes looks to be the best method for disease management. Integrated Disease Management (IDM) is a combined approach which could be a better alternative to minimize the yield losses due to various diseases and farmers should adopt IDM approach to get disease free vegetable crops and higher profitability. Sasane et al. (2012) revealed that in study area 37.50 percent of respondents had adopted recommended plant protection measures for controlling pest, 57.50 percent respondents had partially adopted and 5.00 percent of them had not adopted recommended plant protection measures. Nearly two fifth percent of respondents (36.25%) had adoption on recommended plant protection measures for controlling diseases, 47.50 percent of respondents had partial adoption and 16.25 per cent of them had not adoption on recommended plant protection measures for disease control in cauliflower crop.

Plant protection chemicals used to control downy mildew disease (table-23)

Downy mildew (*Peronospora parasitica*):- The characteristic symptoms of the disease are the appearance of purplish brown spots on the under surface of the leaves. The upper surface of the leaf on the lesion is tan or yellow. The downy fungal growth usually appears on the under surface of the leaves. During the bolting stage, the seed stalks show blackish patches and in severe cases the whole curd is spoiled. The fungus perennates in the infected plant debris as oospores and also as contaminant on the seeds. The plant protection chemicals used, dose applied and percentage of respondents adopted are the followings (table-23):- Mancozeb 75%WP @ 2-3gm /litre of water (42%), Copper Oxychloride 50%WDP @2.5-3.5gm /litre of water (19%), Propiconazole 25%EC @1-2ml /litre of water (14%) and Hexaconazole5%EC@ 1.5-2.5ml /litre of water (9%).

Plant protection chemicals used for controlling black spot or dark leaf spot disease (table-24)

Black spot or dark leaf spot *(Alternaria brassicae):*- The leaf spots are small, lighter dark coloured which spread rapidly to form circular lesion upto 1 cm in diameter or even more. The spots enlarge in concentric rings.

Table-23 Plant protection chemicals used to control downy mildew disease (N=100)

Brand Name	Plant protection chemicals	Recommended dose	Number of respondents adopted	Percentage of respondents adopted	Dose (per litre of water)
Dithane M-45	Mancozeb 75%WP	2.5gm	42	42	2-3 gm
Blue copper	Copper Oxychloride 50%WDP	4gm	19	19	2.5-3.5gm
Pinacle	Propiconazole 25%EC	0.75ml	14	14	1-2ml
Contaf	Hexaconazole5%EC	1ml	9	9	1.5-2.5ml

The fungus may appear as bluish growth in the centre during humid weather. The spots are linear on the stems, petioles and pods. Sometimes the cauliflower heads are infested and show browning at the margin of the individual flower or flower clusters. Minute dark spots may appear on the seedlings stem after germination and cause damping off or stunting of the young plants. The fungi are reported to be seed borne. The plant protection chemicals used, dose applied and percentage of respondents adopted are the followings (table-24):- Mancozeb 75%WP @ 2.5-3gm /litre of water (25%), Carbendazim 50%WP @2-3gm /litre of water (22%), Captan50%WP @2.5-3gm /litre of water (16%), Carbendazim12%+Mancozeb 63% WP @1-2gm /litre of water (8%) and Copper Oxychloride 50%WDP @ 3-4gm /litre of water (14%).

Table-24 Plant protection chemicals used for controlling black spot or dark leaf spot disease (N=100)

Brand Name	Plant protection chemicals	Recommended dose per litre of water	Number of respondents adopted	Percentage of respondents adopted	Applied dose (per litre of water)
Dithane M-45	Mancozeb 75%WP	2.5gm	25	25	2.5-3gm
Bavistin	Carbendazim50%WP	2gm	22	22	2-3gm
Dhanutan	Captan50%WP	2.5gm	16	16	2.5-3gm
Companion	Carbendazim12%+Mancozeb 63% WP	1gm	8	8	1-2gm
Blitox	Copper Oxychloride 50%WDP	4gm	14	14	3-4gm

Plant protection chemicals used to control ring spot disease of cauliflower (table-25)

Ring spot of cauliflower *(Mycosphaerella brassicicola):*- The leaves are normally diseased but the fungus can attack all the living parts. Initially small purple spots appear between the veins or leaves. These spots increase in size to produce concentric rings of affected tissue. The central portion of the spots turns grey from brown. Fungal fruiting bodies appear in concentric rings in these spots. The spot is bordered by a green band which remains green even after the whole leaf has turned yellow. Badly affected leaves fall down. The fungus perpetuates in the seed and in the diseased infested plant debris in the field. The plant protection chemicals used, dose applied and percentage of respondents adopted are the followings (table-25):- Captan50%WP @ 2.5gm/kg of seed for seed treatment (17%), Mancozeb75%WP @2-3gm /litre of water (11%), Copper Oxychloride 50% WDP @3-5gm /litre of water (6%) and Copper Oxychloride 50% WDP 3-5gm /litre of water (2%).

Table-25 Plant protection chemicals used to control fruit ring spot disease of cauliflower :- (N=100)

Brand Name	Plant protection chemicals	Recommended dose per litre of water	Number of respondents adopted	Percentage of respondents adopted	Applied dose (per litre of water)
Captan	Captan50%WP	2.5gm	17	17	2.5gm/kg of seed
Dithane M-45	Mancozeb75%WP	2.5gm	11	11	2-3gm
Blitox-50	Copper Oxychloride 50% WDP	4gm	6	6	3-5gm
Fytolan	Copper Oxychloride 50% WDP	4gm	2	2	3-5gm

Plant protection chemicals used to control watery soft rot or stalk rot disease of cauliflower (table-26)

Watery soft rot or stalk rot (*Sclerotinia sclerotiorum***):-** The disease causes spots on the leaves, particularly on the base of the petioles and passes into the adjoining part of the stem on which large, greyish-white, elliptical spots arise. Sometimes the whole surface of the stem is involved. At the point of attack, the seed stalks can break, wither and eventually die. The fungus survives in the soil on the diseased plant debris. The plant protection chemicals used, dose applied and percentage of respondents adopted are the followings (table-26):- Mancozeb 75%WP @ 2.5-3gm /litre of water (16%), Carbendazim 50%WP @1-2gm/litre of water (12%), Carbendazim 12% +Mancozeb 63% WP @1-2gm/litre of water (5%), Carbendazim 12% +Mancozeb 63%WP@ 1-2gm/litre of water (5%) and Copper Oxychloride50%WDP @ 3-5gm /litre of water (4%).

Table-26 Plant protection chemicals used to control watery soft rot or stalk rot disease (N=100)

Brand Name	Plant protection chemicals	Recommended dose per litre of water	Number of respondents adopted	Percentage of respondents adopted	Applied dose (per litre of water)
Indofil-M-45	Mancozeb 75%WP	2.5g	16	16	2.5-3gm
Cyvistin	Carbendazim 50%WP	1gm	12	12	1-2gm
Companion	Carbendazim 12% +Mancozeb 63% WP	1gm	5	5	1-2gm
SAAF	Carbendazim 12% +Mancozeb 63%WP	1gm	5	5	1-2gm
Blitox	Copper Oxychloride50%WDP	4gm	4	4	3-5gm

Plant protection chemicals used to control browning or brown rot or red rot disease (table-27)

Browning or brown rot or red rot disease:- Browning occurs in cauliflower in which small, concentric water soaked areas develop in the stem and in centre and also on the branches of the curd. The head appears brown and the smaller leaves on the curd become deformed. The stems may become hollow with water soaked tissue surrounding the walls of cavity. In more advanced stages, pinkish or rusty brown areas develop on the surface of the curd. The affected curds develop a bitter taste. The plant protection chemicals used, dose applied and percentage of respondents adopted are the followings (table-27):- Mancozeb 75% WP.@ 2-3gm /litre of water (15%), Mancozeb 75% WP.@ 2-3gm /litre of water (7%), Sodium Borate @1kg/ha (5%), Sodium Borate @10kg/ha (4%).

Table-27 Plant protection chemicals used to control browning or brown rot or red rot disease (N=100)

Brand Name	Plant protection chemicals	Recommended dose per litre of water	Number of respondents adopted	Percentage of respondents adopted	Applied dose (per litre of water)
Uthane M-45	Mancozeb 75% WP.	2.5gm	15	15	2-3gm
Zeb-M-45	Mancozeb 75% WP.	2.5gm	7	7	2-3gm
Borax	Sodium Borate	0.25-0.5 percent solution of Borax @1-2kg/ha in case of acute deficiency	5	5	1kg/ha
Borax	Sodium Borate	20kg/ha	4	4	10kg/ha

Plant protection chemicals used to control whiptail disease (table-28)

Whiptail:- In molybdenum deficient soils the leaf blades of cauliflower do not develop properly and may be straplike. In severe cases only midrib develops. The young cauliflower plants become chlorotic and may turn white, particularly along the leaf margins; they also become cupped and wither. This disorder is caused due to the deficiency of molybdenum occurring mostly in acidic soils where pH is below 5.0. The growing point is severely deformed and hence does not produce marketable curds. Therefore, application of lime in soil is conducive for pH level enhancement which enhances molybdenum availability in soil. The plant protection chemicals used, dose applied and percentage of respondents adopted are the followings (table-28):- Ammonium Molybdate @ 1.5kg/ha (4%) and Sodium Molybdate @1.5kg/ha (1%).

Table-28 Plant protection chemicals used to control whiptail (N=100)

Brand Name	Plant protection chemicals	Recommended dose	Number of respondents adopted	Percentage of respondents adopted	Applied dose
Ammonium Molybdate	Ammonium Molybdate	1.5kg/ha	4	4	1.5kg/ha
Sodium Molybdate	Sodium Molybdate	1.5kg/ha	1	1	1.5kg/ha

Insect-pests and diseases, their attacking stages in cauliflower crop (table-29)

Table-29 Attacking stages of insect-pests and diseases in cauliflower

Insect-pests and diseases	Attacking stages of crop
Insect-pests	
Diamond back moth	Early mature stage
Tobacco caterpillar	Early mature stage to mature stage
Cabbage Butterfly	Mature stage
Cabbage borer	Mature stage
Cabbage aphid	Mature stage
White fly	Mature stage
Diseases	
Downy mildew	Mature stage
Black spot or dark leaf spot	Early mature stage to mature stage
Ring spot of cauliflower	Early mature stage to mature stage
Watery soft rot or stalk rot	Early mature stage to mature stage
Browning or brown rot or red rot	Mature stage
Whip tail	Early mature stage

The table-29 indicates that the cauliflower crop was mainly attacked by insect-pests and diseases at mature stage.

CONCLUSION

To feed the ever-increasing population of our country-to produce more food was main concern. Cultivation of high yielding varieties is an input intensive technology. Therefore, more fertilizers, pesticides, weedicides, irrigation water etc. were applied to field. Gradually, it had become a great problem. Indiscriminate use of chemicals in agriculture during post green revolution period had brought adverse effect on soil health and environment has created an alarming situation. Therefore, the time has come to follow the following considerations those have emerged from the present investigation: - (1) Short-term training on plant protection aspects of cauliflower cultivation should be conducted. (2) Due to fragmentation of land day by day, farmers should choose suitable cropping pattern according to their situations. (3) Farmers need more exposure on plant protection aspects. (4) Farmers are mainly collecting information on plant protection chemicals use from retailers. Therefore the Govt. extension agencies should have a special attention on this section of society. (5) Farmers should have more exposure on mass media. (6) Plant protection chemicals only be applied to the crop when insect-pests infestation crosses the economic threshold level (ETL). (7) Pesticides manufacturers should have more emphasis on liquid chemicals production. (8) Farmers should have more care on crop during mature stage. (9) Farmers should follow various precautions properly in using plant protection chemicals. (10) Cauliflower growers' interval of pesticides use pattern obviously indicates that they are not following precautions properly in pesticides application. (11) according to nature of insect-pests and diseases, soil treatment should also be considered as an important starting point of plant protection measures (12) seed treatment should be considered as an essential activity of cultivation (13) integrated approach is needed to control diamond back moth of cauliflower (14) integrated approach is needed to control downy mildew disease of cauliflower (15) it is observed that farmers are using various brands of a particular chemical considering those as different chemicals. It obviously indicates that farmers have insufficient knowledge regarding various brands of chemicals. (16) generally farmers are not applying recommended doses of plant protection chemicals, therefore, it is an important focus area of extension activities (17) mixed agro-chemicals are gaining popularity day by day due to their effectiveness Application of plant protection measures is a complex technology where farmers' lack of proper understanding (knowledge) make the matter more complex as well as brings psychological disappointment in the mind of farmers. Considering this fact and findings of the present investigation, public and private extension agencies should accelerate their extension activities by focusing more light on plant protection measures of several crops. Susane et al. (2012) suggested that an organized programme in cauliflower production, training, demonstrations and frequent field visits should be taken up by the concern extension agency, so that knowledge and adoption level of recommended production technology of cauliflower growers is enhanced. Jakhar (2014) Farmers commonly use chemical pesticides for controlling insect-pests because chemicals have an immediate knock down effect and are easily available in local market. Spraying of inappropriate chemicals, excessive application, inappropriate timing, the wrong combination of chemicals and spurious chemicals lead to insecticide resistance which causes farmers to spray even more pesticides. Development of insecticide resistance can occurs within one or two cropping seasons after the introduction of a new chemical. Nidhi et al. (2016) reported that technical guidance should be provided regarding assessment of ETL, training on IPM technologies should be imparted, more number of demonstrations on IPM should be organized on farmers' field and trycoderma should be made available at local market were important strategies suggested by the farmers in the study area.

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