controlled by destroying the caterpillars 3-5 times through hand-picking starting from 3 weeks after cabbage or cauliflower transplantation. For successful control of diamond back moth and *Prodenia* caterpillars the following steps should be followed: (a) Firstly, begin inspecting the cabbage and cauliflower plants starting from three weeks after transplanting; (b) Secondly, inspect the plants by turning over the lower leaves to look for the caterpillars; (c) Thirdly, pick up and crush any caterpillar that are found; and (d) Lastly, repeat this practice twice a week until harvest. The caterpillars that cannot be destroyed by hand-picking are killed by the natural enemies. In extreme cases, however, when the infestation is severe, one or two spot applications with malathion may be considered. Farmers of our country visit their vegetable fields 2-3 times a week and they can easily adopt this practice and destroy the caterpillars 3-5 times during their field visits. Cabbage or cauliflower crops will suffer minimal damage from the attack of these pests by using this practice and farmers can produce healthy cabbage or cauliflower crops and earn more by avoiding insecticide use. Comparative results of IPM practice and farmers' practice with regard to pest damage, pest control cost, cabbage yields and farmers' net income are presented in Tables 1, 2 and 3.

Table 1. Effects of IPM practice in cabbage crop in farmers' fields at Daklapara village in Burichong Upazilla of Comilla.

Effects of pest control measures	IPM method Destruction of caterpillars by hand-picking - 4 times	Farmers' practice Insecticide spray-10 times
Cabbage heads damaged	10%	33%
Pest control cost (Tk/ha)	2,240 (6,197 less costly)	8,437
Cabbage yield (t/ha)	105 (13 t/ha higher yield)	88
Farmers' net income (Tk/ha)	1,73,633 (39,305 higher income)	1,34,328

Table 2. Effects of IPM practice in early cabbage crop in farmers' fields at Kodalia village in Sadar Upazilla of Jessore.

Effects of pest control measures	IPM method Destruction of caterpillars by hand-picking - 5 times	Farmers' practice Insecticide spray-11 times
Cabbage heads damaged	2%	12%
Pest control cost (Tk/ha)	2,800 (3,798 less costly)	6,598
Cabbage yield (t/ha)	26 (3 t/ha higher yield)	23
Farmers' net income (Tk/ha)	1,67,272 (26,970 higher income)	1,40,302

Table 3. Effects of IPM practice in early cabbage crop in farmers' fields at Gondol village in Burichong Upazilla of Comilla.

Effects of pest control measures	IPM method Destruction of caterpillars by hand-picking - 5 times	Farmers' practice Insecticide spray-8 times
Cabbage heads damaged	6%	21%
Pest control cost (Tk/ha)	4,888 (4,439 less costly)	9,327
Cabbage yield (t/ha)	23 (4 t/ha higher yield)	19
Farmers' net income (Tk/ha)	1,39,084 (34,742 higher income)	1,04,342

It is clear from the above on-farm results that the infestations of diamond back moth and *Prodenia* caterpillar can be easily and effectively controlled by adopting the IPM method and the farmers can obtain higher cabbage yields and economic returns with minimal or no pesticide use. It is important to note that production of pesticide-free healthy cabbage through IPM method will contribute to maintain better health of the consumers as well as the producers and open opportunities for export markets.

Cabbage crop grown by farmers by using IPM method

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IPM Method to Control Diamond back Moth and *Prodenia* Caterpillar for Healthy and Pesticide-free Production of Cabbage

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IPM Method to Control Diamond Back Moth and *Prodenia* Caterpillar for Healthy and Pesticide-free Production of Cabbage

Cabbage is a popular and widely cultivated winter vegetable in Bangladesh. It is rich in vitamin A, a crucial element for the prevention of blindness in children. Every year about 30,000 children in Bangladesh suffer from blindness due to lack of vitamin A. Cabbage therefore plays a vital role in meeting the nutritional requirement of the human body. Presently, cabbage occupies about 11,000 ha producing 115,000 tons per year, the average yield being only about 10 tons per ha. One of the major factors for low cabbage yields is the heavy damage done by two leaf-eating insects, the diamond back moth (*Plutella xylostella*) and Prodenia caterpillar (*Prodenia litura*).

Description of the pest insects and damage: The adult of the diamond back moth is a small moth that has a 'diamond' like spot on its back and hence is the name 'diamond back moth'. The adult of the *Prodenia* caterpillar also a moth, is medium-sized and grey colored. Only the caterpillars of these two insects can damage the crops. In addition to damaging the cabbage heads, the caterpillars of the diamond back moth can attack cauliflower and mustard crops. The *Prodenia* caterpillars can damage cauliflower, tobacco, potato, sweet potato, groundnut, tomato, chilies, cowpea, jute, and arum in addition to cabbage.

The female moth of the diamond back moth lays eggs singly or in batches of 2-3 eggs on the under surface of cabbage or cauliflower leaves. The caterpillars hatch out from the eggs in 3-8 days depending on the prevailing air temperatures. Initially, the freshly hatched caterpillars

Adult of diamondback moth

Caterpillar of diamndback mont

Cabbage damaged by diamondback moth caterpollar

start feeding on the leaves where the eggs were laid or on the adjacent leaves. As they grow, they then move and start feeding on the central leaves that form the cabbage heads. As a result of feeding, the plants either fail to form compact cabbage heads, or form incomplete heads. The caterpillars, when fully grown, transform in to pupae within silky cocoons. A fully-grown diamond back moth caterpillar is 8mm long with bulged stomach and is green in color. The adult moths emerge from the pupae in about a week. The diamond back moth caterpillars damage the cauliflower heads (curds) the same way as they do on the cabbage heads.

Adult moth of Prodenia litura

Caterpillar of Prodenia litura

Cabbage damaged by Prodenia caterpillar

The female moths of the *Prodenia* caterpillar lay a number of eggs in a cluster on the under surface of cabbage leaves which are covered by light brown hairs. Emerging from the eggs in 3-4 days, the freshly hatched caterpillars altogether start feeding on the lower leaves by scrapping and the damaged leaves take a 'sieve-like' appearance. As the caterpillars grow, they disperse to other cabbage plants and start feeding on the central leaves and as a result the plants fail to form compact cabbage heads. Depending on the prevailing air temperature, the caterpillars become fully grown in about 2-3 weeks and drop on the soil to transform in to pupae within a hard cocoon. The full-grown caterpillars are 40-45mm long and blackish in color with yellow-green stripes across the surface of the body. The adult moths emerge from the pupae in about 10 days.

Farmers' current practice to control cabbage pests: Presently, the farmers in Bangladesh rely solely on the use of toxic pesticides in an effort to protect their cabbage and cauliflower crops from the attack of diamond back moth and *Prodenia* caterpillar. Unfortunately, the farmers fail to achieve satisfactory control of the pests in spite of weekly or fortnightly applications of insecticides, because the insecticide sprays that are applied over the cabbage or cauliflower crops can not kill the caterpillars as they initially remain and feed on the under-surface of the lower leaves. Secondly, the insecticide sprays prove ineffective, as the insecticide residues cannot reach the caterpillars when they reach the folded central leaves. As a result, the surviving caterpillars continue their feeding and damage the crops. Thirdly, the caterpillars become tolerant or resistant to insecticides due to frequent applications. Recent surveys have shown that the diamond back moth has become resistant to almost all the insecticides that are used in Asia. Fourthly, insecticide applications kill the natural enemies, and as a result, the diamond back moth and *Prodenia* caterpillar perpetuate freely in absence of any natural control systems.

Most insecticides are harmful to human health. The pesticide residues that remain on the cabbage and cauliflower crops are potentially hazardous to the consumers to cause various health problems. Additionally, the farmers who are involved in insecticide applications also can be affected by the poisonous actions of the insecticides.

Farmers' practice with pesticides

IPM Method for Diamond Back Moth and *Prodenia* Caterpillar Management: On-farm trials and demonstrations carried out for four years at different sites by the scientists of the Bangladesh Agricultural Research Institute (BARI) through IPM CRSP program have shown that diamond back moth and *Prodenia* caterpillar can be successfully controlled by adopting IPM methods without resorting to pesticide use. The caterpillars of these two pests attack the cabbage or cauliflower plants usually three weeks after transplantation. As mentioned earlier, most of the caterpillars escape toxic effects of insecticide sprays as they feed on the under-surface of the lower leaves at the early stage of infestation and then move to the folded central leaves. As a result, insecticide use turns to be largely unsuccessful for controlling these pests. On the other hand, the infestations of the diamond back moth and *Prodenia* caterpillar can be easily and successfully