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EFFECT OF CHEMICAL PESTICIDES ON THE GROWTH AND YIELD OF TWO INDUSTRIAL POTATO VARIETIES (ASTERIX AND COURAGE) IN BANGLADESH

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Abstract

Experiments were conducted to find out suitable disease management practices to produce quality potato seeds in processing the varieties of Asterix and Courage in Bangladesh. A set of two field experiments was conducted in two different Agroecological zones of Bangladesh. A Factorial Randomized Completely Block Design with 2 potato varieties, 4 treatments, and 4 replications for each were used. A significant difference was found in the plant height and number of tubers per hill. In contrast, days to tuberization and the number of stems per hill of both varieties in response to pesticide application were insignificant. The highest tuber yield and better A and B-grade tubers were recorded, in which fungicides and insecticides were applied. The primary viral infection had been identified in the control and fungicide-treated plots only while there was no viral disease incidence was observed in the insecticide-treated plots. The incidence of post-harvest disease and disorder was found to be negligible.

Key words: Asterix, Courage, Fungicides, Insecticides, Potato, Tuber.

Introduction

Potato is a very important and high-yielding crop in Bangladesh. Data from the Bangladesh Bureau of Statistics (BBS) revealed that the total potato production was approximately 1.04 crore tons from 4.55 lakh hectares of land in 2022-2023 (BBS 2023). Potato is used for different purposes for instance, fresh consumption as boiled, fried, and baked; processed as French fries, and potato chips; in the industry as food additives, pharmaceutical, textile, and paper; and seed potatoes (FAO 2008). Potato is susceptible to a wide range of pathogenic organisms, which can cause significant yield losses. The most important fungal diseases are early blight, stem canker, and powdery scab in our country; however, the oomycetes pathogen, *Phytophthora infestans*, can damage the crop within a week. A total of seven potato viruses, *Potato leafroll virus* (PLRV), *Potato virus X* (PVX), *Potato virus Y* (PVY), *Potato virus S* (PVS), *Potato virus H* (PVH), *Potato aucuba mosaic virus* (PAMV) and *Potato virus M* (PVM) infection have been found in Bangladesh so far (Khan et al. 1991, Rashid et al. 2020). These viral diseases cause a lower yield of potatoes remarkably. Aphids are considered the major agent of transmission of viral diseases in potato fields. In Bangladesh, Aphid-*Myzus persicae* started appearing in the third week of December and reached its population peak in the fourth week of February (Khan and Bari 1981). A strong and significant quadratic polynomial relationship existed between temperature and aphid population build-up in the potato field. The relationship between relative humidity and aphid population build-up in the field was found to be significant but negatively

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correlated. The increase of the aphid population in the field was positively correlated with the spread of PLRV and PVY in the potato field which indicates that an environmental factor affects the aphid population and virus transmission in potato fields (Hasan and Rashid 2015). Primary infection of PVY and PLRV in an early stage of development of a crop can cause considerable and almost comparable to that caused by secondary infection (De Bokx and van der Want 1987). Yield loss due to infection of PVY in the variety of Cardinal was 80.31 - 83.15% and in the variety of Diamant 79.51 - 81.15% (Hossain and Ali 1992). It has been reported that 100% infection of PLRV caused 78% yield loss (Hossain et al. 1994), and only 30% infection with PVY in the variety Cardinal 35% yield loss was recorded (Hossain and Ali 1993). The potato is the most fungicides and pesticide-dependent crops worldwide (Yuen 2021). Over 103 fungicides and 160 insecticides have been registered in Bangladesh until 2020 against different pests and diseases (Bangladesh Crop Protection Association 2024). In this context, several fungicides and pesticides were applied alternately per spray schedule to assess their impact on the quality of seed potato production of two processing potato varieties Asterix and Courage in Bangladesh.

Materials and Methods

The experiment was conducted at the Domar Foundation Seed Potato Production Farm, Nilphamari, and Farmer's Field, Kashimpur, Gazipur, Bangladesh. The soil was highly acidic (pH 5.4) at Kashimpur, Gazipur whereas slightly acidic (pH 6.04) at Domar Seed Potato Farm. The study used two popular industrial potato Varieties, namely Asterix & Courage. The foundation class of seeds of both varieties was used in the study. Factorial Randomized Completely Block Design in which 2 potato varieties and 4 treatments with 4 replications were used as layout. The plot size was 2 m × 3 m each. The following treatment combinations were used for both industrial potato varieties (Asterix and Courage) are mentioned in Table 1.

Table 1: Schedule of fungicides and/or insecticides spray in the experimental field.

Treatments	1st spray	2nd spray	3rd spray	4th spray	5th spray	6th spray	7th spray
Control	Nill	Nill	Nill	Nill	Nill	Nill	Nill
Fungicides (T_1)	Mencozeb	Mencozeb	Mencozeb	Mencozeb	Acrobat	Secure	Metataf
Insecticides (T_2)	Asataf	Asataf	Asataf	Asataf	Admire	Admire	Admire
Fungicides+ Insecticides (T_3)	Mencozeb + Asataf	Mencozeb + Asataf	Mencozeb + Asataf	Mencozeb + Asataf	Acrobat + Admire	Secure + Admire	Metataf + Admire

Mencozeb@ 2 kg/ha; Acrobat @ 2 kg/ha; Secure @ 1 kg/ha; Metataf @ 1 kg/ha; Asataf @ 0.5 kg/ha; Admire @ 0.5 kg/ha were used in the current study. Control = no fungicides and insecticides, T_1 = solely fungicides, T_2 = solely insecticides, and T_3 = both fungicides and insecticides.

The experimental field was ploughed mechanically and leveled properly to have good tilth. Tuber Crops Research Center (TCRC), Bangladesh, recommended the inorganic fertilizer dose/ha. Based on the suggestions of TCRC, half of the urea and half-murate of potash and the whole quantity of triple super phosphate were applied to the soil of the growing potato crops as the top dressing after 35 days of planting of seed potato. The foundation seed potato was collected from the BADC. The seed potato was kept in a defused light in a storeroom for about 72 hours for pre-sprouting. Then, the grade A (28-40 mm) seed tubers

were cut into two pieces and grade B (41-55 mm) seed tubers were cut into 2-3 pieces and kept the cut tubers to a cool shady place for 48-72 hours for healing or suberization, before planted them in the experimental potato field. Row-to-row distance of 60 cm and a tuber-to-tuber distance of 20 cm was maintained. Mulching and weeding were carried out after 20 days of planting. Just after mulching, the first irrigation was done. Moreover, 8 times irrigation were done in Domar potato seed production farm and 4 times irrigation were given to a Farmer's field at Kashimpur. Data were taken on days to tuberization, the number of stems/hills at 60 days after sowing (DAS), plant height (60 DAS), the number of tuber/hills, and tuber weight/hill at the time of harvest. The potato plants were uprooted. After haulm pulling, the potato was kept on the field for 10 days for hardening of the skin. The potato was harvested and taken to a cool shady place where sorting, grading, and weighting were done. Data were analyzed using Statistix 10 software.

To study the incidence of post-harvest disease and disorders of the seed potato produced in the experimental field at Kashimpur, Gazipur, and Domar BADC farm, Nilphamari, seeds were brought to BADC cold storage, Kashimpur, Gazipur, Bangladesh. To record the post-harvest potato disease incidence, 6 samples each of which contained 500 tubers of each variety were checked. The properly labeled samples were put into 80kg hessian gunny bags of kept them in the pre-cooling chamber at Kashimpur BADC cold storage at 12-15ºC for 72 hours. Before shifted them to the cooling chamber of the cold storage at 2.2-2.8ºC for the 2011-12 preservation season. In the 2nd week of November 2011, the potato bags were taken to the pre-heating chamber at 12-15ºC and kept the bags there for 72 hours before taking them to the sorting shed at ambient temperature and fanned for 72 hours. Finally, the potato bags were opened, and data were taken for the incidence of diseases (dry rot, soft rot, gangrene and hallow heart) and disorders (bruised) of potatoes.

Results

Days to tuberization, number of stem/hills, plant height, number of tubers/hill

Early tuberization of 26.25 days was obtained in all the treatments of the variety of Courage in Domar Farm which was statistically significant compared to the variety of Asterix (Table 2). The maximum days of tuberization of 43.50 were observed in the treatment T_1 of Asterix in Domar Farm which was statistically like T_1 and T_3 of Asterix (Table 2). The highest number of stem/hill (4.50) was obtained in the treatment of T_2 and control in the variety of Courage at Domar Farm which was statistically similar to the rest of the treatments for both varieties (Table 2). On the other hand, the highest number of stem/hill 4.42 was obtained in the control variety of Asterix, which was statistically similar to the rest of the treatment of both varieties in the Kashimpur Farmer's field. Results indicate fungicides and insecticides sprayed on plants did not affect the increment of the number of stems/hills.

The maximum plant height (64.50 cm) of the variety of Asterix was found of T_2 at Domar farm which was statistically similar to T_3 but differed from T_1 and the control (Table 3). On the other hand, in the case of the variety of Courage, the highest plant height (50.92cm) was observed in T_1 at Domar farm which was statistically similar to the rest of the treatments. The maximum number of tuber per hill was 13.75 in the treatment of T_3 of Asterix which was statistically highly significant compared to other treatments in Domar farm, followed by T_2 of Asterix and Courage (Table 3). The least number of tubers (6.25) were obtained in the control of Asterix which was statistically similar to the control of Courage. In Kashimpur Farmer's field, the largest number of tuber per hill (14.75) was found in the treatment T_1 of Asterix, and the lowest number of tuber (11.17) per hill was observed in control of Courage.

Table 2: Effect of four pesticide treatments on the days to tuberization and number of stems per hill of two industrial potato varieties grown at different locations.

Treatments	Tuberization				Number of stems per hill			
	Domar		Kashimpur		Domar		Kashimpur	
	Asterix	Courage	Asterix	Courage	Asterix	Courage	Asterix	Courage
Control	36.00ab	26.25c	28.75a	25.25b	4.00a	4.50a	4.42a	3.75a
T_1	43.50a	26.25c	29.25a	25.26b	4.00a	4.25a	4.00a	3.75a
T_2	33.25b	26.25c	28.50a	25.00b	4.25a	4.50a	4.33a	3.58a
T_3	36.25a	26.50c	29.00a	25.00b	4.00a	4.00a	4.17a	4.08a
LSD (p<0.05)	2.768		1.025		1.105		1.025	

Values with the same letters within rows and columns are not significant (p<0.05); Here, Control: no fungicides and insecticides; T_1: solely fungicides treated plants; T_2: solely insecticides treated plants; T_3: both fungicides and insecticides treated plants.

Table 3: Effect of four pesticide treatments on the plant height and number of tubers per hill of two industrial potato varieties grown at two different locations.

Treatments	Plant height (cm)				Number of stems per hill			
	Domar		Kashimpur		Domar		Kashimpur	
	Asterix	Courage	Asterix	Courage	Asterix	Courage	Asterix	Courage
Control	44.42c	50.75bc	46.83b	40.25d	6.25d	7.00d	13.09b	11.17d
T1	51.00bc	50.92bc	46.50b	41.25c	10.50bc	9.75c	14.75a	12.08bcd
T2	64.50a	49.41bc	47.34ab	41.50c	12.00b	11.75b	12.75bc	12.58bc
T3	59.00ab	51.16bc	47.75a	40.83c	13.75a	11.00bc	12.67bc	11.83cd
LSD (p>0.05)	11.45		0.871		1.705		0.946	

Values with the same letters within rows and columns are not significant (p<0.05); Here, Control; T_1: solely fungicides treated plants; T_2: solely insecticides treated plants; T_3: both fungicides and insecticides treated plants.

Tuber weight (g)/hill, grade-wise yield (g)/plot

The greatest tuber weight of 465 g per hill was found in the treatment of T_3 of Asterix which was statistically similar to the same treatment (T_3) of Courage and T_2 of Asterix in the Domar Farm (Table 4). The least tuber weight of 111.58 g per hill was observed in the control of Courage. In the Kashimpur farmer's field, there was a maximum tuber weight of 453.33g per hill in the treatment (T_3) of Courage where both fungicides and

insecticides were sprayed, followed by the same treatment of Asterix. The lowest number of tuber weights per hill was obtained in both control treatments of Asterix and Courage in the Kashimpur Farmer's field.

In the Domar farm (Fig. 1), the highest A-grade tuber was found in all treatments (control, T_1, T_1 and T_3) of variety-Asterix, and the lowest A-grade tuber was obtained in the variety of Courage (Fig. 1). Likewise, the highest B-grade tuber yield was obtained in T_1; followed by T_3 of the variety of Asterix and the lowest B-grade tuber yield was observed in the control and T_2 of variety Courage. The highest oversized tuber yield was found in T_1 and T_3 of the both varieties.

On the other hand, at Kashimpur farmer's field (Fig. 2), the highest A-grade tuber yield was found in the all treatments of the variety of Courage; followed by variety of Asterix and the lowest A-grade tuber yield was observed in T_3 of the variety of Courage (Fig. 2). The highest B-grade tuber yield was obtained in T_2 in the variety of Aesterix; followed by control and T_3 in the variety of Aesterix. In the case of the variety of Courage, the maximum B-grade tuber was observed in T_1 and T_3; followed by T_2 and control.

Table 4: Effect of four pesticide treatments on the tuber weight (g)/hill and percentage increase over control of two industrial potato varieties grown at two different locations.

Treatments (T)	Domar		Kashimpur	
	Asterix	Courage	Asterix	Courage
Control	300.75bc	111.58d	380.83g	381.67g
T1	382.50ab	221.66c	436.67c	392.50e
T2	461.66a	340.00b	435.00d	385.84f
T3	465.00a	459.16a	446.34b	453.33a
LSD (p>0.05)	91.72		1.175	

Values with the same letters within rows and columns are not significant (p<0.05); Here, Control; T_1: solely fungicides treated plants; T_2: solely insecticides treated plants; T_3: both fungicides and insecticides treated plants.

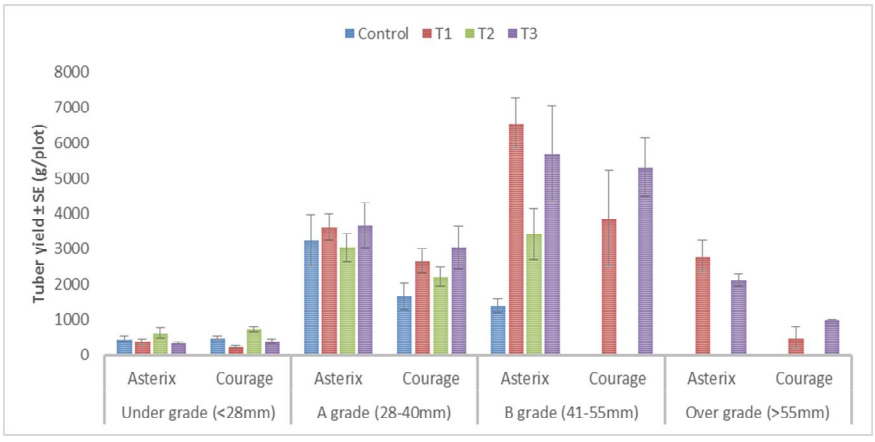

Fig. 1: Grade-wise yield (g/plot) of two processing varieties under pesticidal treatment at Domar farm. Here, SE denotes standard error of four replications; Control; T_1: solely fungicides treated plants; T_2: solely insecticides treated plants; T_3: both fungicides and insecticides treated plants.

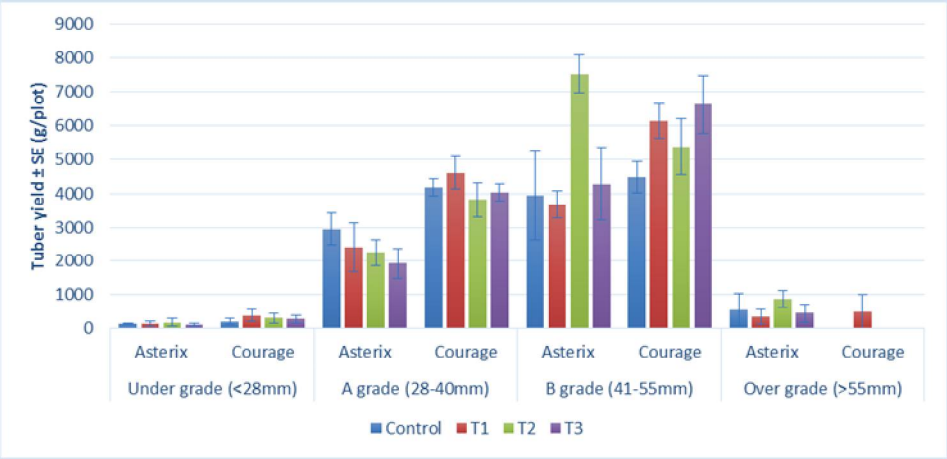

Fig. 2: Grade-wise yield (g/plot) of two processing varieties under pesticidal treatment at Kashimpur farmer's field. Here, SE denotes standard error of four replications; Control; T_1: solely fungicides treated plants; T_2: solely insecticides treated plants; T_3: both fungicides and insecticides treated plants.

Prevalence of diseases in the field, incidence of post-harvest diseases and disorders

In the Domar farm, there was the presence of primary infection of the virus in both varieties of Asterix and Courage (Table 5), where there were no fungicides and insecticides sprayed (Control) plants, as well as only fungicides, sprayed plants (T_1). Interestingly, primary infection of the virus was zero in both varieties where only insecticides were sprayed (T_2) and fungicides and insecticides sprayed plants (T_3). Similar trends of findings were observed in Kashimpur Farmer's Field regarding primary infection of the virus. The results indicate that insecticides might reduce or control the aphid population which is responsible for the spread of the virus in the potato field. In the Domar farm, late blight diseases were prevalent in the control of both the varieties and in the case of treatment T_1 of Asterix but we could not observe late blight infection in the treatment T_1 of Courage where fungicides were sprayed. Surprisingly, there was no late blight of potato infection in the Kashimpur Farmer's field.

Table 5: Prevalence of diseases on two processing varieties of potato grown in two different locations.

Treatment	Domar				Kashimpur			
	Primary infection of virus (%)		Infection of late blight disease (%)		Primary infection of virus (%)		Infection of late blight disease (%)	
	Asterix	Courage	Asterix	Courage	Asterix	Courage	Asterix	Courage
Control	3	2.5	0.5	0.25	2	2.75	0	0
T_1	2.5	2	0.25	0	1.25	1.5	0	0
T_2	0	0	0	0	0	0	0	0
T_3	0	0	0	0	0	0	0	0

Control; T_1: solely fungicides treated plants; T_2: solely insecticides treated plants; T_3: both fungicides and insecticides treated plants.

Soft-rot disease was not detected in the sample of Kashimpur farmer's field and Domar BADC farm (Table 6). Dry rot disease incidence (0.4%) was found in potato variety of Asterix while this diseased potato was not detected in the variety of Courage. There were some bruised tubers in all the cases which occurred due to harvesting. A negligible amount of gangrene and hallow heart disorder of tuber were also observed.

Table 6: Incidence of post-harvest diseases and disorders of potato.

Sampling location	Variety	Number of tubers in the sample	Number of tubers affected by disease and disorders.				
			Bruised tuber	Dry rot (*Fusarium* sp.)	Soft rot (*Pectobacterium* sp.)	Gangrene (*Phoma* sp.)	Hollow heart
Kashimpur farmer's field	Asterix	500	4	2	-	-	1
	Courage	500	2	-	-	2	-
Domar BADC farm	Asterix	500	3	2	-	1	1
	Courage	500	2	-	-	1	1

Discussion

In the present study, three different types of foliar contact fungicides with preventive and curative actions were used. Contact fungicides do not penetrate the plant cell and remain on its surface, and their main action is to suppress the reproductive organs of the target pathogen, and the protective effect lasts for around 8 days. Systemic action fungicides penetrate the plant, active substances enter the plant within the first 30 minutes after application and remain effective for 10-14 days (Schepers van Soesbergen 1995, Lazarchuk 2015). The use of protectants and systemic fungicides for managing late blight has perhaps been the most studied aspect of late blight management in temperate countries (Olanya et al. 2001). In our study, as a preventive spray, Mancozeb @2 kg/ha was sprayed either alone (T_1) or combined with Asataf (T_3) during 1st to 4th spray on the potato field. The number of tubers and tuber weight per hill increased significantly in both fungicides and insecticide-treated plants. Moreover, the prevalence of late blight disease and primary viral infection was lower where fungicides and insecticides were applied. Our results conform with the previous findings. The application of fungicides helped not only to reduce the spread of both early and late blight disease incidence, but also to increase the total yield, tuber quality, dry matter contents, and ascorbic acid significantly compared to those without fungicides application (Sayuk et al. 2022). The contact fungicide Mancozeb is known to reduce the incidence of late blight disease and increase of significantly the potato yield (21.26 tons/ha) in Bangladesh (Rahman et al. 2008). For the commercial production of potatoes, the application of mancozeb resulted in the suppression of the late blight severity of more than 50% and an increased yield of more than 30% compared to the control (Kankwasta et al. 2002). On early blight-susceptible cultivars, responses to fungicide applications were found to be highly significant with yield increases of as much as 127% (Teng and Bissonnette 1985). Spray programs of 4-6 applications of fungicides (boscalid, azoxystrobin, and difenoconazole) inhibited the development of disease and improved marketable tuber yields of over 20% compared with unsprayed plots in South Australia, Western Australia, and Queensland (Horsfield et al. 2010). In another study, twice the application of contact fungicide (mancozeb) treatments significantly reduced late blight progress, with a corresponding increase in tuber yield (Namanda et al. 2004). Moreover, three times spray and alteration of fungicide application instead of single

fungicide (2-3 times spray and mancozeb alter with acrobat/mancozeb alter with propineb) proved to be more effective in reducing late blight infection and increasing potato yield (Dey et al. 2010). The highest tuber yield was obtained from the plots, after twice fungicidal spraying while the lowest tuber yield was recorded from the untreated plot (Kassaw et al. 2021). Field trials showed that the tuber yield was found to be significantly increased with the application of fungicides and pesticide-treated plants compared to control (Khadka et al. 2020).

In the current study, the fungicide Secure (Chemical name: Fluazinam) was used during the 6th sprays in the potato field. Fluazinam has been reported as one of the most effective fungicides against late blight in Europe. This fungicide interrupts the zoospores activities of the pathogen and blocks the energy production process via an uncoupling effect on oxidative phosphorylation (Schepers et al. 2018). In our study, insecticide- Asataf @0.5 kg/ha plus fungicide Mancozeb was sprayed on the potato field during the 1st to 4th spray as per the spray schedule. Asataf is a 75% SP formulation of Acephate, which is one of the versatile organophosphate insecticides with both contact and systemic action: particularly effective on severe infestations of sucking and chewing insects of different crops. Significantly lowest mean thrips (sucking pest) rating (0.37-0.72) was observed in treatments with Asataf 75 SP @ 0.10% under greenhouse conditions (Kaur and Singh 2013). At 50% of the recommended dosage of Acephate, the remarkable efficacy of 70% control or better against the two most common aphids, *M. persicae* and *M. euphorbiae* of potatoes (Visser and Majola 2010). Acephate gave good efficacy against melon aphids (*Aphis gossypii)* on the zinnia in three greenhouse trials and against green peach aphids-*Myzus persicae* (Amitava and Santanu 2005, Vea and Palmer 2015). In our study, insecticides Admire @0.5 kg/ha were applied on a spray schedule to control the aphid population (vector for viral diseases) in the field and were found to increase the growth and yield parameters of both potato varieties- Asterix and Courage. Besides, the prevalence of primary viral infection and late blight diseases was not found in either fungicides or insecticide-treated plants at Domar and Kashimpur farms. The *M. persicae* gained high importance due to the virtue of the vector of viral diseases (Blackman and Eastop 2000), including potato virus Y (PVY) and potato leaf roll virus (PLRV). In our study, insecticide- Admire @ 0.5 kg/ha plus fungicide-Secure@1 kg/ha and Admire@0.5 kg/ha plus Metataf @1 kg/ha were applied during the 6th to 7th spray in the potato field to control both oomycete and insect as per spray schedule. Admire Pro (Chemical name: imidacloprid**)** is known as a soil-applied highly effective insecticide providing long residual control of insect pests of potatoes namely Colorado potato beetles, aphids, and psyllids (Schreiber et al. 2023). This significantly suppressed the *Myzus persicae* population by 74.92% on potato fields and increased the significantly higher production of potatoes (Khan et al. 2011).

In earlier studies, both systemic (imidacloprid) and contact insecticides (lambda-cyhalothrin and flonicamid) were reported to be effective at intoxicating aphids (three aphid species, *Macrosiphum euphorbiae, Rhopalosiphum padi*, and *Aphis fabae*) and reducing probing behavior or PVY acquisition soon after application; might be responsible for sporadically reduce the spread of PVY, however, their action is likely limited to a short period after application (Boquel et al. 2015). In this experiment, multiple fungicides and insecticides were sprayed in an alternate fashion resulting in the highest growth and yield parameters, especially where both fungicides and insecticides were sprayed, compared to only fungicides or only insecticides or control. The reasons behind the higher yields of potatoes are linked with healthy potato plants, suppression of the aphid population, result in the reduction of the spread of viral diseases, and free from oomycetes and viral diseases.

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