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Particle film technology for insect pest management in potato

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ABSTRACT

An experiment was conducted under AICRP on potatoes at OUAT, Bhubaneswar, on potato variety 'Kufri Ashoka' using the particle film technology against major insect pests. Kaolin was applied as a foliar spray at different concentrations (1.25%, 2.5% and 3.75%) under black polythene mulch and non-mulch conditions. Based on the pooled mean over two seasons, the effectiveness of both the concentrations of kaolin (2.5% and 3.75%) were found to be statistically at par concerning the management of whiteflies (6.4 to 7.0 white flies/plant) irrespective of mulching of the plots and comparable to imidacloprid 17.8 SL @ 0.03% (2.3 to 2.7 whiteflies/plant). A similar trend of equal effectiveness against jassids was also observed in the experiment. Reduction in cutworms and Epilachna beetle populations revealed that these chewing insects avoided the leaves sprayed with kaolin irrespective of their concentrations. However, kaolin @ 2.5% treatment in non-mulching situations recorded a higher benefit: cost (B: C) ratio (1.70), which is very close to that of standard chemical treatment imidacloprid 17.8 SL @ 0.03% (1.79). The SPAD reading showed no decrease or increase in chlorophyll content pattern after kaolin spray on potato leaves. So considering the bio-efficacy against sucking and chewing insect pests, kaolin @ 2.5% spray in non-mulching conditions was the most efficient.

Keywords: Potato, Particle film technology, Pest management, Kaolin

INTRODUCTION

India is the second largest producer of potato following China. The area under potato cultivation in India is 2.18 million hectares with production of 48.61 million ton as compared to global area of 19.302 million hectare and production of 388.19 million ton during 2017. In Odisha, potato is cultivated over an area of 25.03 thousand hectare with production of 2.94 lakh tons and productivity of 12.04 metric tons per hectare during 2017. The state of Odisha requires 12 lakh MT of potato every year which is four times of its own production and thus depends on neighboring states like West Bengal and Uttar Pradesh to meet the additional requirement. Short supply of potato from the exporting states sometimes leads to rise in potato prices causing burden on consumers. So, there is need for expansion in both area and production of potato in Odisha. Potato is the most important vegetable consumed by the people of Odisha and has an important place in the dietary composition. It is highly nutritious, easily digestible, wholesome food containing carbohydrates, proteins, minerals, vitamins and high quality dietary fiber. A potato tuber contains around 78 percent water, 16 percent starch, 2 percent sugar, 2 percent protein, 0.6% minerals, 1.0 percent fiber, 0.1 percent fat, and vitamin B and C in adequate amount.

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Insect pest menace is one of the major factors that destabilize potato crop productivity. Sucking insect pests like white flies (*Bemisia tabaci* Gennadius), jassids (*Amrasca sps.*) and aphids (*Myzus persicae* Sulzer and *Aphis gossypii* Glover) cause crop loss directly. Aphids can transmit different viruses in potato. Among foliage feeders, Hadda beetle (*Epilachna vigintioctopunctata*) and potato cut worm (*Agrotis ipsilon* Fabricious) are important. Particle film technology has emerged as a new method for controlling pests and diseases of horticultural crops in organic, integrated and conventional pest management (Andrew, 1). Particle film technology involves Kaolin-based sprays that deposit a "particle film" over leaves. It has numerous beneficial effects on plants. It helps in insect pest control and forms a highly reflective white film over plant surface that enhance plant photosynthesis and reduce heat stress by reflecting the infra-red light spectrum. Kaolin is a white non-porous, non swelling, low abrasive, fine grained, plate-shaped alumino-silicate natural mineral that easily disperses in water and is chemically inert. When kaolin particles cling to the body, insects struggle in moving over kaolin treated surfaces which reduces feeding and oviposition (Glenn and Puterka, 2). Kaolin creates a barrier film by covering the leaves and fruits with a white powdery film, which adheres and irritates insects resulting insect pest reduction. Tarsal segments of insects are covered

with kaolin particles (Glenn *et al*., 3). It does not hamper honeybee activity or other beneficial insects. It affects by interfering with feeding behavior and egg-laying, increasing mortality and concealing the crop. Kaolin is not toxic for beneficial insects (Showler and Setamou, 4).

Organic production of high quality agricultural and horticultural products still remains difficult. Most of the pesticides are classified as toxic or irritating and cause a threat to the workers, neighbours, beneficial organisms, animals, environment and finally to the consumers. Particle film technology may be an effective and potential tool against major insect pests of potato in organic farming.

MATERIALS AND METHODS

The experiment was conducted at AICRP on Potato, OUAT, Bhubaneswar during *Rabi* 2015-16 and 2016-17 in potato variety 'Kufri Ashoka'. The experiment was laid out in Randomized Block Design with two factors and four replications. The first factor 'A' comprised of two treatments such as mulching (M_1) and no-mulching (M_0). Black colour plastic mulch was used to cover the soil in specified treatments after potato plants emerged. The second factor 'B' comprised of untreated control (T_1), Imidacloprid 17.8 SL @0.03% (T_2), Kaolin @ 1.25% (T_3), Kaolin @ 2.5% (T_4) and Kaolin @ 3.75% (T_5). Foliar spray of kaolin and imidacloprid was done at 30 and 45 days after planting (DAP). Normal agronomic practices were adopted with fertilizer dose of 150-80-100kg N, P_2O_5 and K_2O/ha. Population of sucking insect pests (whiteflies and jassids/leafhoppers) was counted on three fully expanded compound leaves (top, middle and bottom) per plant in ten fixed plants of each treatment plot. The foliage feeders (potato cut worm and epilachna beetle) were counted per plant in ten fixed plants of each treatment plot. Observations were taken at three and seven days after each spray. Mean of all the observations were calculated for all the insect pest population in each treatment plot. SPAD reading was taken at three days after each spray on three fully expanded compound leaves (top, middle and bottom) per plant in ten fixed plants of each treatment plot. Potato tubers were harvested and yield was recorded in each treatment, separately.

RESULTS AND DISCUSSION

The results indicated that the insect pest damage was significantly decreased in kaolin treated plots. Among sucking insect pests, white flies and jassids were found to be associated with the crop during the entire experimental seasons. Among the foliage feeders, cut worms and epilachna beetles were found to be the major ones. The nature of damage during cropping seasons and efficacy of different treatments has been presented below:

White flies are the sucking type of insects. Both the nymphs and adults suck sap from the young tender leaves and twigs of potato plants. Apart from their direct feeding they may also transmit viral diseases. During the experimental season *Rabi* 2015-16, mulching and non-mulching condition had not shown any significant difference with respect to whitefly population. Kaolin @ 2.5% (T_4) and kaolin @ 3.75% (T_5) performed at par in efficacy against whiteflies both in non- mulching (7.2 and 6.9 whiteflies/plant) and mulching conditions (6.9 and 6.4 whiteflies/plant), while Imidacloprid 17.8 SL @ 0.03% (T_2) recorded the lowest of 3.1 and 2.8 whiteflies/plant. Untreated control plots registered 16.2 and 15.7 whiteflies/plant in both mulching and non-mulching situation. During *rabi* 2016-17, the results reflected in Table-1 reveal that whitefly population in Treatment-4 (kaolin @ 2.5%) in no-mulch plot was 6.8 whiteflies/plant which differ significantly from Treatment-5 (kaolin @3.75%), where 6.3 whiteflies/plant was recorded. Similar trend of effectiveness was recorded in mulched plots. However the standard chemical treatment; Imidacloprid 17.8 SL @0.03% (T_2) reduced the population to 2.3 to 1.8 whiteflies/plant compared to18,5 to 19.1 whiteflies/plant in untreated control plots.

Pooled mean of two seasons proved the statistically similar effectiveness of both the concentrations of kaolin (2.5% and 3.75%) regarding management of whiteflies (6.4 to 7.0 whiteflies/plant) irrespective to mulching. These treatments were observed to be very much effective as compared to untreated control (17.4whiteflies/plant).

Jassids/leaf hoppers are sucking type of insects that cause hopper burn in severe cases if not managed properly.

During the experimental season *rabi* 2015-16 the jassids/leafhopper population ranged from 14.8 and 15.0 jassids/plant in untreated control condition. Treatment-5 (Kaolin @3.75%) recorded lowest population of 7.6 jassids/leafhopper) in non-mulched plots and 7.5 jassids/leafhopper) in mulching condition followed by Treatment-4 (Kaolin @2.5%), where 8.0 and 8.1 jassids/leaf hopper were noted. Chemical treatment; Imidacloprid 17.8 SL @0.03% (T_2) had lowest population (2.3 and 2.4 jassids/leaf hopper) in the experiment.

During *rabi* 2016-17, results reflected in Table-1 shows that kaolin @2.5% (T_4) and kaolin @3.75% (T_5) performed at par in hopper management (6.4 & 6.0jassids/plant in no mulching and 6.3 and 5.8 jassids/plant in mulching treatments). The range of

Table 1. Population of White flies and Jassids in different treatments (mean of observations at 3 and 7 days after each spray)

Treatment	No of white flies/plant			No. of jassids/plant		
	Rabi, 2015-16	*Rabi*, 2016-17	Mean	*Rabi*, 2015-16	*Rabi*, 2016-17	Mean
M_0T_1	16.2	18.5	17.4	14.8	15.6	15.2
M_0T_2	3.1	2.3	2.7	2.3	1.2	1.8
M_0T_3	8.4	9.4	8.9	9.8	8.2	9.0
M_0T_4	7.2	6.8	7.0	8	6.4	7.2
M_0T_5	6.9	6.3	6.6	7.6	6	6.8
M_1T_1	15.7	19.1	17.4	15	14.5	14.8
M_1T_2	2.8	1.8	2.3	2.4	1.0	1.7
M_1T_3	9.1	8.2	8.6	9.0	8.5	8.8
M_1T_4	6.9	6.5	6.7	8.1	6.3	7.2
M_1T_5	6.4	6.3	6.4	7.5	5.8	6.7
CD Factor (A)	NS	NS	NS	NS	NS	NS
CD Factor (B)	1.129	0.781	0.639	0.530	0.960	0.530
CD Factor (A×B)	NS	NS	NS	NS	NS	NS

Factor 'A' = Mulching (M_1) and no-mulching (M_0).
Factor 'B'= Untreated control (T_1), Imidacloprid 17.8 SL @0.03% (T_2), Kaolin @ 1.25% (T_3), Kaolin @ 2.5% (T_4) and Kaolin @ 3.75% (T_5).

population during the experimental season was 15.6 and 14.5 jassids/plant recorded in untreated control plots.

Pooled mean population of jassids derived from two experimental seasons reflects the statistically similar bio-efficacy of both concentrations of kaolin (2.5% and 3.75%). David *et al* (2000) had given similar opinion that kaolin was highly effective in preventing sucking insect like citrus thrips. Pre flowering application of kaolin is a promising suitable method to keep European pear sucker under its economic threshold throughout the season which indicates that it can be an alternative to broad spectrum insecticides (Daniel *et al.*, 3). These are the foliage feeders. Both adults and young grubs destroy the leaves of young tender plants.

During the experiments the mean population of epilachna beetle/hadda beetle in untreated control plots were 2.0 to 2.5 beetles/plant. Kaolin @2.5% (T_4) and kaolin @3.75% (T_5) could reduce the population to 0.5 to 1.0 beetles/plant. In case of epilachna beetle also the mulching treatment had not created any significant difference (Table-2).

Data on observations during *Rabi* 2016-17 clearly showed the effectiveness of both the concentrations of kaolin (2.5%and 3.75%) in management of beetles. Pooled mean result proves that both the concentrations of kaolin (2.5%and 3.75%) are at par in beetle management.

Cutworms may cut off the stems of potato plants during young vegetative stage. Later in the season they feed on foliage. After tuberization the tubers that are exposed on the soil surface or get damaged. Data on cutworms presented in Table-2 reflects that cutworms avoided the leaves sprayed with kaolin irrespective of concentrations. Kaolin have a barrier or repellent effect against insects (Putreka *et al*., 2000). Mulching with black polythene had no significant effect. Rather it provided shelter place for hiding during day time. Larvae were noticed under the polythene mulching.

Marketable potato tuber yield recorded during *rabi* 2015-16 reflects that kaolin (2.5% and 3.75%) are found to be statistically at par in both mulching and non-mulching situation. Highest yield (183q/ha) was achieved in non-mulching plot where the recommended chemical Imidacloprid 17.8 SL @0.03% was applied. However the plots treated with kaolin (2.5% and 3.75%) had recorded satisfactory yield (173q/ha to176q/ha) compared to 134q/ha tuber yield in untreated control plot.

During *rabi* 2016-17 kaolin treatments had shown similar trend of tuber yield achievement. Kaolin @3.75% recorded highest yield (178q/ha and 179q/ha) in mulching and non mulching condition among the three doses applied.

Pooled mean yield of two season experiment indicated that kaolin (2.5%and 3.75%) are found to be statistically at par in both mulching and non mulching situation which is slightly inferior than the standard chemical treatment imidacloprid 17.8 SL @0.03% but far superior than the untreated control treatment.

Table 2. Population of Epilachna beetle and Potato cutworms in different treatments (mean of different observations at 3 and 7 days after each spray)

Treatment	Number of epilachna beetles /plant			Number of cutworms /plant		
	Rabi, 2015-16	*Rabi*, 2016-17	Mean	*Rabi*, 2015-16	*Rabi*, 2016-17	Mean
M_0T_1	2.0	3.0	2.5	2.5	3.3	2.9
M_0T_2	0.3	0.5	0.4	0.3	0.5	0.4
M_0T_3	1.0	1.5	1.3	1.3	1.7	1.5
M_0T_4	0.5	1.0	0.8	1.0	1.5	1.3
M_0T_5	0.5	0.5	0.5	1.0	1.3	1.2
M_1T_1	2.5	3.5	3.0	2.0	3.5	2.8
M_1T_2	0.5	1.0	0.8	0.3	0.3	0.3
M_1T_3	2.0	2.5	2.3	1.6	2.0	1.8
M_1T_4	1.0	1.0	1.0	1.3	1.6	1.5
M_1T_5	1.0	0.5	0.8	1	1.5	1.3
CD Factor (A)	NS	NS	NS	NS	NS	NS
CD Factor (B)	0.407	0.449	0.288	0.410	0.370	0.279
CD Factor (A×B)	NS	NS	NS	NS	NS	NS

The economic analysis depicted in Table 3 shows that highest gross return (Rs179,000/ha) was achieved in the treatment (T_2) imidacloprid 17.8 SL @0.03% in no mulching condition. In mulching condition, kaolin @3.75% (T_5) and the treatment T_2(imidacloprid 17.8 SL @0.03%) were at par in gross return (Rs 176,000/ha). The insect pest management system in non mulching condition was proved to be economialy viable. In non mulching condition, the standard chemical treatment M_0T_2(imidacloprid 17.8 SL @0.03%) achieved maximum net profit (Rs 78,760/-) followed by Rs 71,500/- in M_0T_4 (kaolin 3.75%) and Rs 71,250/- in M_0T_5 (kaolin 2.5%). However the kaolin 2.5% treatment in non-mulching situation (M_0T_2) recorded benefit cost (B:C) ratio (1.70) which is very closure to the highest (1.79) benefit cost (B:C) ratio achieved in standard chemical treatment imidacloprid 17.8 SL @0.03% (M_0T_2).

The mean SPAD reading of both the seasons depicted in Table-3 shows no pattern of decrease

Table 3. Marketable potato tuber yield, economics and SPAD reading in different treatments.

Treatment	Marketable potato tuber yield (q/ha)			Gross return (@ Rs 1000/q) (Rs/ha)	Gross cost (Rs/ha)	Net return (Rs/ha)	B:C ratio	SPAD reading in leaves
	Rabi, 2015-16	*Rabi*, 2016-17	Mean					
M_0T_1	134	136	135	135000	100000	35000	1.35	17.1
M_0T_2	183	176	179	179000	100240	78760	1.79	17.3
M_0T_3	166	164	165	165000	101250	63750	1.63	19.2
M_0T_4	173	172	174	174000	102500	71500	1.70	21.0
M_0T_5	176	178	175	175000	103750	71250	1.69	19.0
M_1T_1	140	134	137	137000	150000	-13000	0.91	18.4
M_1T_2	179	174	176	176000	150240	25760	1.17	20.0
M_1T_3	165	167	166	166000	151250	14750	1.10	23.3
M_1T_4	175	173	174	174000	152500	21500	1.14	20.5
M_1T_5	173	179	176	176000	153750	22250	1.14	23.3
CD Factor (A)	NS	NS	NS					0.441
CD Factor (B)	5.058	4.699	3.398					0.698
CD Factor (A×B)	NS	NS	NS					0.987

or increase in chlorophyll content after application of Kaolin in potato leaves. David *et al* (2000) had given similar opinion that Kaolin did not interfere with photosynthesis or stomatal conductance and may possess yield enhancement qualities.

Kaolin sprays are used internationally for specific insect pests and sunburn problems in apples, pear, citrus, pomegranates, and vegetables. Kaolin is generally regarded as safe to humans and has long history of use in the paint, plastics, pharmaceutical and paper industry. Kaolin sprays are used for pest control and sunburn protection in both conventional and organic food production in the United States and abroad (en.wikipedia.org).

So considering the bio-efficacy against both sucking and chewing insect pests, yield, economics and ecosafety, particle film technology which comprises kaolin @2.5% spray in non mulching condition was found to be most efficient one. So this may be included in organic potato cultivation at Odisha condition. Kaolin spray may be an alternative to the insecticides used to management of both sucking and chewing insect pests in potato.

AUTHORS' CONTRIBUTION

Conceptualization of research (Sasmal A.); Designing of the experiments (Sasmal A. and Mishra A.); Contribution of experimental materials (Mishra A.); Execution of field/lab experiments and data collection (Sasmal A. and Mishra A.); Analysis of data and interpretation (Sasmal A. and Sarangi P.K.); Preparation of the manuscript (Sasmal A. and Mishra A.).

DECLARATION

The authors declare no conflict of interest.

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