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Effect of different colours of polyethylene mulch and sticky paper traps on disease incidence and yield of bellpepper under protected cultivation

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Abstract
Aphid and aphid borne virus diseases cause extensive losses to many horticultural and agricultural crops. A study was conducted to evaluate the efficacy of different colours of polyethylene mulch and coloured sticky paper traps in combination with insecticide imidacloprid (0.25ml/l) for the management of aphid and aphid borne virus disease (Bellpepper Mosaic Virus) and its effect on bellpepper yield. The studies revealed that use of reflective mulch in combination with insecticide and yellow trap resulted in minimum mean aphid population 2.33 per leaf/ plant, lower disease incidence (3%) of bellpepper mosaic virus with maximum fruit yield (5.5kg/plant) whereas highest aphid population 20.11 per leaf/ plant with maximum disease incidence (15%) and minimum fruit yield (1.5 kg/plant) were recorded in control. Results from the present study suggests that combination of insecticide imidacloprid (0.25ml/l) with reflective mulch can suppress aphid population thereby reducing the disease incidence of bellpepper mosaic virus as well as help in increasing fruit yield of bellpepper.

Keywords: Aphid, Bellpepper Mosaic Virus, fruit yield, reflective mulch, insecticide

Introduction
Capsicum (*Capsicum annuum* var. *frutescens*) which is also known as sweet pepper, bell pepper or green pepper is one of the most popular and highly remunerative vegetable crops grown throughout the world. It differs from hot chilli in size, fruit shape, capsaicin content and usage. About 35 species of insect and mite pests reported in capsicum, a few viz., thrips, aphids, whitefly, fruit borers and mite causing severe problems. In addition to injuries from direct feeding, problems from this pest are intensified because it vectors over 100 plant viruses (Jones, 2003) [11]. Several studies demonstrated are reduction in infestation by insect pests and incidence of insect-vectored viral infection in vegetable crops by the use of reflective mulch (Kousik *et al.*, 2008) [13]. The primary targeted insects in reflective mulch studies have been virus vectors such as aphids, thrips and whiteflies. Silver or gray reflective mulches have been used successfully to delay and reduce the incidence of aphid borne virus diseases in squash and other crops (Brown *et al.*, 1993 [5]; Stapleton and Summers, 1997; Stapleton *et al.*, 1994; Summers and Stapleton, 1998, 1999 [16]; Summers *et al.*, 1995 [17]; Webb and Linda, 1992). These mulches reflect short-wave light which repels incoming alate aphids, thus reducing their incidence of alighting on plants (Kring, 1969) [12]. Brown *et al.* (1993) [5] and Summers *et al.* (1995) [15] found silver (aluminum) plastic mulch superior to white in repelling aphids. Plants grown over reflective mulch produced significantly higher yields of marketable fruit than did those grown on bare soil (Brown *et al.*, 1993 [5]; Summers *et al.*, 1995) [15]. Additional advantages of mulches include soil moisture and temperature modifications which may result in increased crop earliness, growth, and yield, providing greater benefit and cost effectiveness to the grower (Stapleton *et al*., 1993) [15]. Halima and Hamouda (1994) [9] reported that aphids are the major pests of capsicum. Lately, white fly has also emerged as the major pest in the protected conditions causing huge losses to the farmers. Imidacloprid is widely recommended for the control of white fly and aphids inside polyhouses. Imidacloprid is a systemic insecticide which acts as an insect neurotoxin and belongs to a class of chemicals called the neonicotinoids which act on the central nervous system of insects, with much lower toxicity to mammals. The chemical works by interfering with the transmission of stimuli in the insect nervous system. Specifically, it causes a blockage of the nicotinergic neuronal pathway. By blocking nicotinic acetylcholine receptors, imidacloprid prevents acetylcholine from transmitting impulses between nerves, resulting in the insect's paralysis and eventual death. It is effective on contact and via stomach action (Anonymous, 2012) [1]. Because imidacloprid binds much more strongly to insect neuron receptors than to mammal neuron receptors,

this insecticide is more toxic to insects than to mammals (Anonymous, 2005) [2].

As of 1999, Imidacloprid was the most widely used insecticide in the world (Anonymous, 2010) [3]. Although it is now off patent, the primary manufacturer of this chemical is Bayer Crop Science (part of Bayer AG). It is sold under many names for many uses; it can be applied by soil injection, tree injection, application to the skin of the plant, broadcast foliar, ground application as a granular or liquid formulation, or as a pesticide-coated seed treatment(Anonymous. 2013 [4];

Brown *et al*. 1993) [5]. Imidacloprid is widely used for pest control in agriculture. Recent research suggests that widespread agricultural use of imidacloprid and other pesticides may be contributing to honey bee colony collapse disorder, the decline of honey bee colonies in Europe and North America observed since 2006 (Irwin and Ruesink,1986 [10]; Halima and Hamouda, 1994 [9]; Gervais, *et al*., 2010) [8]. As a result, several countries have restricted use of imidacloprid and other neonicotinoids (Gervais, *et al*., 2010) [8]. In January 2013, the European Food Safety Authority stated that neonicotinoids pose an unacceptably high risk to bees, and that the industry-sponsored science upon which regulatory agencies' claims of safety have relied, may be flawed, or even deceptive (Kring, 1969 [12]; Jones, 2003) [11]. At present, it is feared that the repeated applications and indiscriminate use of different pesticides by the farmers for the control of pests may lead to the development of resistance in whitefly, aphid and mite. In order to impede the development of insecticide resistance and its harm on the beneficial insects (read bee) apart from human health, it is always advisable to use insecticides in rotation as well as in combination with other cultural practices. The objective of this study was to assess the effectiveness of different colours of polyethylene mulch and sticky paper traps for the management of aphid and aphid borne virus in bellpepper under protected cultivation.

Materials and Methods

The investigation was conducted in the experimental field of the Precision Farming Development Centre, Department of Soil Science and Water management, Dr. Y S Parmar University of Horticulture and Forestry, Nauni Solan during 2013-2015 in a polyhouse measuring 200m^2. Capsicum seedlings were transplanted in the month of March during 2013-14 and 2014-15 under polyhouse with a plot size of 6 m^2 (3 m × 2 m) under Completely Randomized Block design in three replications. Different coloured sticky traps were placed in every plot @ 2 per replication except in two plots and were placed horizontally at a height of 25.0 cm. For mulch treatment black and reflective polyethylene mulch of 25 µ thickness having holes of 60 mm diameter was spread over the prepared plots and capsicum seedlings were transplanted in the holes. Treatments were replicated thrice in a completely randomized design. One spray of insecticides imidacloprid (0.25ml/l) was included in all the treatments.

The various treatments included – T_1- Reflective mulch + insecticide, T_2- Black mulch+ insecticide, T_3- Reflective mulch + insecticide+ yellow trap, T_4- Reflective mulch + insecticide+ orange trap, T_5- Reflective mulch + insecticide+ blue trap, T_6- Black mulch + insecticide+ yellow trap, T_7- Black mulch + insecticide + orange trap, T_8- Black mulch +insecticide+ blue trap, T_9 (Control) insecticide + yellow trap. Plants were sampled weekly, beginning at the first true leaf stage, by selecting one young, fully expanded leaf per plant, gently turning it over, and visually counting the number of alate aphids present on the lower surface at 3 DAS (days after spraying), 7 DAS and 10 DAS with the insecticide in all the treatments. Counts were taken in the cool of the morning which reduced the tendency of the alate aphids to fly when disturbed. Imidacloprid was sprayed 4 times at 15 days interval @ 0.5 ml/lt. The disease incidence was recorded by visual observations after the first appearance of symptoms and per cent incidence was determined per treatment by dividing the number of infected plants by the total number of plants in each treatment. At each harvest fruit yield (kg/plant) was also recorded.

Results and Discussion

Data as presented in Table1, revealed significant differences among different treatment with respect to aphid population, disease incidence of bellpepper mosaic virus and fruit yield of capsicum. The first aphid count was taken at the first true leaf stage. All reflective mulches performed equally well in repelling incoming alates, significantly reducing the number alighting on those plants growing over the reflective mulches, compared to those growing on non-reflective mulch treatment (Table 1).The pooled data indicated that significant low aphid counts 2.33 per leaf/ plant was recorded in T_3 treatment and highest aphid population was recorded in 23.43 per leaf/ plant T_9 treatment (Control). Plants growing over unmulched soil quickly became infected with one or more viruses.

In the present investigation, an increase in disease incidence coincided with the build-up of aphid population. Minimum disease incidence (3%) was also recorded in T_3 treatment where there were low aphid populations and maximum disease incidence was recorded in T_9 (15%) where there were maximum aphid population. Irwin and Ruesink (1986) [10] listed eight events which must occur before a plant becomes infected with an aphid-borne virus. Each event has its own probability of success. In these studies, only vector abundance was measured and no other factors such as vector propensity or activity were measured as, generally, vector density only directly influences virus spread (Irwin and Ruesink, 1986) [10]. Total yield per plant of capsicum was achieved highest (5.5 kg/plant) in T_3 treatment followed by T_1 and other treatments while control recorded lowest yield of 1.5 kg/plant. These results suggest that all mulch treatments were clearly superior to the unmulched beds with respect to fruit production but the use of reflective mulches significantly reduced the aphid landings and disease incidence compared to other treatments. The results of this study clearly demonstrated the effectiveness of reflective mulch in limiting aphid populations and reducing the incidence of bellpepper mosaic virus. The reflective mulch strategy has wide applicability in conventional farming as well as organic farming. The use of reflective mulches could reduce or eliminate the need for insecticide applications and in turn reduce the number of accidental insecticide poisonings. Reflective mulches have been used successfully to manage aphids and whiteflies in a variety of vegetable crops and also proven effective in reducing the incidence of aphid-transmitted virus diseases (Brown *et al*. 1993 [5]; Summers and Stapleton 1998) [16]. Nevertheless, it would seem that both types of mulches can be useful tools in production agriculture (Stapleton *et al.,* 1993) [15].

Thus, it is concluded that use of reflective mulches in combination with yellow sticky trap can be used as an alternative management strategy in situations where chemicals create a hazard and can also provide a tool for control of aphid and aphid-transmitted virus diseases.

Table1: Efficacy of different treatments on aphid population, disease incidence and yield of capsicum during 2014-15.

Treatment	No. of aphids/leaves /plant				Disease Incidence (%)	Yield (Kg/Plant)
	3DAS	7DAS	10DAS	Pooled mean		
T1	5.0	7.0	6.0	6.0	6	4.9
T2	10.0	12.0	11.0	11.0	12	2.4
T3	2.3	3.3	4.3	3.3	3	5.5
T4	5.1	4.1	3.1	4.1	7	4.6
T5	4.1	5.1	6.1	5.1	8	4.5
T6	11.0	8.0	9.0	9.3	7	3.8
T7	10.0	9.0	11.0	10.0	9	2.5
T8	11.1	12.1	13.0	12.0	9	2.4
T9	20.1	21.1	29.1	23.43	15	1.5
SE (m)±	0.401	0.386	1.630	0.100	0.577	0.200
$CD_{0.05\%}$	1.202	1.157	0.544	1.843	1.729	0.599

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