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# Management Of Urd Bean Leaf Crinkle Virus In Urd Bean (*Vigna Mungo* L. Hepper)

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## ABSTRACT

Six plant extracts viz., *Mirabilis jalapa, Carthamus roseus, Datura metal, Bougainvillea spectabilis, Boerhaavia diffusa and Azadirachta indica* recorded maximum reduction in the incidence of urd bean leaf crinkle virus (ULCV) in urd bean crops at field level. Among the antiphytoviral chemicals tested, DHT reduced the transmission to the maximum extent and increased the incubation period of virus in the urd bean plant. Fresh buttermilk was significantly superior to fermented buttermilk in reducing the disease spread and increasing the incubation period of the virus in the plant. Casein was found effective in reducing the per cent transmission and increased the incubation period of the virus. Raising barrier crops viz., maize, sorghum and pearl millet were equally effective in reducing the spread of the disease in field. Spraying of DHT at two intervals, 7 and 22 DAS was found effective in reducing the disease spread when compared with *Thuja*, buttermilk, *M. jalapa* and *neem oil*.

**Key words** : Urd bean Leaf crinkle virus.

## INTRODUCTION

The urd bean (*Vigna mungo* (L.) Hepper) is commonly known as black gram. Most urd bean cultivars produce black-colored seeds. The urd bean is a staple crop in India, Burma, Bangladesh, Pakistan, and Thailand (Lawn and Ahn 1985; Rubatzky and Yamaguchi 1997). Urd bean plant becomes a victim of a large number of diseases caused by both fungi and viruses. Among the virus diseases, Urd bean leaf crinkle virus (UCLV) is considered to be the most serious one causing considerable damage to the crop depending on season and variety cultivated. Studies on management of urd bean leaf crinkle virus by using botanical, antiphytoviral chemicals and animal products are the important areas which needs focused research.

## MATERIALS AND METHODS

*Effect of chemicals, plant and animal products on infection*

*Pot culture studies using chemicals:*

Urd bean seeds of T9 variety were sown in 9 inch diameter pots in glasshouse and were thinned to five plants/pot. Aqueous solutions of 0.1per cent DHT (2,4-dixohexahydro 1,3,5-triazine), carbendazim and benzoic acid, 0.02per cent salicylic acid acetyl salicylic acid and 2per cent Thuja (an aurvedic preparation) were sprayed on 10 day old seedlings. Plants were inoculated with infective sap for 24 hr before inoculation at 0 hr (mixing equal quantities of chemical and infective sap) and 24 hr after inoculation and five days after inoculation. A total of 18 plants were inoculated for each treatment. Checks were maintained by inoculating with infective sap alone. Number of infected plants and incubation period were recorded 30 days after inoculation to find out the effects of different chemicals on virus infection.

*Pot culture studies with animal products :*

Three types of buttermilk viz., fresh, 1 and 2 day-fermented samples were taken and diluted 10-fold with water. Casein was dissolved in small quantity of 0.1N NaOH and then diluted to 2, 3 and 4per cent with water. They were sprayed on urd bean plants following the method described under effect of chemicals.

*Pot culture studies with plant products :*

Fresh leaves of Four-o' clock plant (*Mirabilis jalapa* L.), Algaroba (*Prosopis chilensis* (Molina) Stuntz.), Sadahdhatura (*Datura metel* L.), Coconut (*Cocos nucifera* L.), Sorghum (*Sorghum bicolor* (L.) Moench.), Bougainvillea (*Bougainvillea spectabilis* Wild.), Safflower (*Catharanthus roseus* (L.) G. Don.), Pongam (*Pongamia pinnata* (L.) Pierre.), Indian spinach ( *Basella alba* L.), Horse-purslane ( *Boerhaavia diffusa* L.), and Neem ( *Azadirachta indica* A. Juss.), were collected. Coconut and sorghum leaves were air dried and ground into powder

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and the inhibitor was extracted by heating 10 g powder in 50 ml water at 70°C hot water bath for 30 min. The leaves of other plants were homogenized in a pestle and mortar by adding 4 ml of distilled water/g. The extract was then squeezed through muslin cloth.

An equal quantity of each extract and infective sap were mixed and inoculated on of 10 days old urd bean seedlings. The control plants were inoculated with infective sap alone. Thirty plants were inoculated for each plant extract. Number of infected plants, incubation period and percent infection were recorded.

*In field :*

Field trials were conducted with plot size of 4 x 3 m in four replication in kharif season with 0.1per cent DHT, 2 per cent Thuja, 10per cent fresh buttermilk and leaf extracts of Four-o' clock plant *(Mirabilis jalapa)*. Leaf material from healthy *M. jalapa* plants was collected and macerated with water @ lt/kg. The resultant pulp was passed through two folds of muslin cloth and extract made up to 10 lt. To 1 lt water, 10 ml Neem oil and 1 ml teepol was added and shaken well to emulsify the solution. They were sprayed on plants with a knapsack sprayer until drip off occurred. The control plots were sprayed with water. Two sprays were given on 7 and 22 days after planting (DAP). The number of diseased plants were counted at weekly intervals from 20 to 60 DAS. The crop was not sprayed with any insecticide or fungicide. Experimental plot size was 4 x 3 m in four replications.

*Barrier crops :*

Maize (Ganga 5), sorghum (Co. 26) pearl millet (Co. 6) and urd bean T9 were sown against the wind direction in two rows each on north and south sides of the urd bean plot in kharif season. Between them, the control plot had eight rows of urd bean without barrier crop. Between two treatments, three rows of urd bean seeds were sown to serve as outskirts. The plot size was 4 x 5 m with five replications with 30 x 10 cm spacing for urd bean, 60 x 30 cm for maize and 45 x 15 cm for sorghum and pearl millet. The number of infected plants was recorded at weekly interval from 25 to 60 DAS. The percent infection was calculated per plant population in each plot. The grain yields of urd bean and barrier plants were also recorded.

## RESULTS AND DISCUSSION

*Effect of chemicals, plant and animal products under pot culture condition*

*Plant extracts :*

Since the antiviral principles (AVP) present in leaf extracts of several plants are known to inhibit infection by many viruses, the efficacy of 11 plant extracts on the percent transmission of this virus was tested. It was observed that the leaf extract of *Mirabilis jalapa* reduced transmission by 30 per cent as against 80per cent recorded in control followed by *Carthamus roseus* (40per cent). *Datura metal*, *Bougainvillea spectabilis*, *Boerhavia diffusa* and *Azadirachta indica* each recorded 50 per cent infection (Table-1). All the leaf extracts increased the incubation period. However, the maximum increase of 8.8 days was recorded by *Mirabilis jalapa* leaf extract.

The AVP present in leaf extracts of several plants are known to inhibit infection by the viruses Rayachaudhuri and Prasad, (1965); Varma, (1974); Singh and Singh, (1975); Narayanasamy and Ramaiah (1983). Antiviral principles from *M. Jalapa* Murthy, (1982), *Prosophis specigera* Nagarajan and Murthy, (1977), *Bougainvillea spectabilis* and *Basella alba* Murthy et al., (1981) were found effective against TMV. Chowdhury and Saha (1985) found that the Urd bean leaf crinkle virus (ULCV) was inhibited by *D. metal* leaf extract to the extent of 30 per cent over control. It was observed that *M. jalapa* showed better inhibition (30 per cent) than *D. metal* (50 per cent). The effect has been attributed to inhibitory principles present in the leaf extracts. Consequently, the number of virus particles entering the plant might have been reduced. Similar observations have been made by White and Antoniw (1983) indicating that inhibitors of plant virus infections may affect plants directly or interfere with a host-virus interaction, which is essential for infection. Prasad (1986) observed some alterations in enzyme activity during induced antiviral state. These are some of the possible ways by which the plant extracts prevent viral diseases.

The results obtained in the present investigation have indicated a great potential of plant extracts for the management of the disease. Further work to identify the active component involved and its purification and formulation will offer a practical method of virus disease management.

*Effect of antiphytoviral chemicals :*

It was observed that DHT, benzoic acid, carbendazim and Thuja significantly reduced the per cent transmission over control (Table-2), showing that plants treated with DHT, Carbendazim and Thuja recorded only 48, 57 and 50per cent mean infection respectively as compared to 77 control. The time of application of these chemicals did not significantly influence infection. The lowest (25per cent) percent infection was observed when DHT was mixed with the inoculum. All chemicals except benzoic acid delayed the onset of symptoms significantly over control (Table 2). DHT delayed symptom expression by 7.5 days when mixed with the inoculum. Regarding time of application of the chemicals, it was observed that the incubation period significantly increased when the chemicals were applied at all times except 5 days after inoculation. The maximum increase in incubation period was 21 days when chemicals were mixed and applied with the inoculum. There was significant interaction between inoculation time and chemicals (Table-2).

Considering the fact that it is virtually impossible to

free plants from virus after infection, research was directed at reducing the disease severity and preventing virus establishment by use of chemicals that do not affect host plants. Antiviral chemicals can act in various ways either by complexing chemically modifying and / denaturing, dissociating, hydrolyzing or precipitating the viruses. Many chemicals were reported to act as inhibitors of virus replication in plants. Schuster *et al.* (1979) showed marked

Table 1 : Effect of plant extracts on ULCV transmission

| Plant species | Plants infected out of 10 | Incubation period(days) | Percent infection |
|---|---|---|---|
| *Mirabilis jalapa* | 3 | 26.6 | 30(32.7) |
| *Prosophis chilensis* | 6 | 23.0 | 60(50.7) |
| *Datura metel* | 5 | 26.0 | 50(45.7) |
| *Cocos nucifera* | 7 | 20.4 | 70(56.3) |
| *Sorghum bicolor* | 7 | 20.8 | 70(56.3) |
| *Bougainvilla spectabilis* | 5 | 26.2 | 50(45.7) |
| *Carthamus roseus* | 4 | 26.3 | 40(39.4) |
| *Pongamia pinnata* | 6 | 21.4 | 60(50.7) |
| *Basella alba* | 6 | 22.0 | 60(50.7) |
| *Boerhaavia diffusa* | 5 | 23.3 | 50(45.7) |
| *Azadirachta indica* | 5 | 23.0 | 50(45.7) |
| Control | 8 | 17.8 | 80(62.7) |

C.D (P=0.05)

Figures in parenthesis are arcsine transformed values

decrease in the concentration of PVX, PVY and CMV in tobacco plants when sprayed with DHT two days before inoculation and 2-7 days after inoculation. Periodical assay of the treated plants for the titre of the virus will throw light on the mechanism of action of DHT against the present virus.

Similarly, carbendazim reduced percent infection while incubation period was prolonged when applied as foliar spray 24 hours before and 24 hours and five days after inoculation (Table-2). Tomlinson et al (1976) has reported treatment of tobacco and lettuce plants with carbendazim that prevented development of two virus diseases namely bean Western yellows and TMV in lettuce and tobacco respectively. The effectiveness of benlate in reducing the transmission of ULCV has been reported by Bhardwaj *et al.*, (1982). Although the mode of action of benzimidazoles in suppressing symptoms is not clearly understood, it is known that these compounds can bind to chloroplast membrane and delay chloroplast senescence and act like cytokinins Waygood, (1965); Tripathi and Schlosser, (1977). It is therefore, possible that the symptom suppressive effect of benlate is due to its cytokinin related antisenescent properties.

*Buttermilk:*

Since the protein present in skim milk has been reported to reduce transmission of TMV due to the presence of casein. The transmission of this virus as influenced by buttermilk was also studied in a pot culture experiment. It was seen that there was significant reduction in per cent infection by all types of buttermilk over control (Table-3). Fresh buttermilk gave the lowest transmission of 44.5per cent as compared to 83.4per cent in control. There were significant differences between the types of buttermilk used. Fresh buttermilk was significantly superior to fermented buttermilk.

Among the different times of application of buttermilk, the lowest infection was obtained when it was applied to the plant by mixing with infective sap, followed by inoculation before 24 hr and after 24 hr. The interaction between the time of application and buttermilk types was not significant. The incubation period also increased significantly over control in all types of buttermilk tested. Fermentation of buttermilk for 48 hr delayed onset of symptoms to the maximum extent *viz.*, 3.9 days followed by 3.0 days in 24 hr fermented buttermilk. There was significant increase in incubation period when different types of buttermilk were applied at different times as compared to control. The highest incubation period of 22.52 days was recorded with buttermilk mixed with inoculum followed by 18.5 days when buttermilk was applied before 24 hr compared to 16.5 days in control. The interaction between time of application and buttermilk types was not significant.

The reduction in disease due to buttermilk was probably due to the blocking of receptor sites by the protein present in buttermilk or due to the inhibition of virus multiplication or both. The former might have lead to reduction in disease while prolonged latent period was due to decreased rate of multiplication of the virus in the plant after infection. Tomaru and Ohkawa (1985) have reported casein inhibited transmission of CMV to tobacco by *M. persicae*. Buttermilk contained 3.1 g protein / 100

g (Gopalan *et al.*, 1985). Another possible cause for reduced transmission by using buttermilk may be the pH. The present study revealed that when buffer with pH less than 5 was used for sap transmission, only 16.6 per cent inoculated plants were infected against 80per cent in buffer of pH 7.5 (Fig. 1). This indicates that buffer in acid range is inhibitory to the virus. Therefore the inhibitory effect by fresh and fermented buttermilk can be attributed to the acidic pH in the range 4.4 – 3.9.

*Casein :*

Since the protein present in buttermilk is casein, the effect of this proximate constituent on transmission of the virus was studied. From the data presented in Table 4, it can be seen that among the different times of application, mixing inoculum with casein gave lowest infection and per cent transmission *viz.*, 54.2 against 89.9per cent in control. Other periods of application did not significantly reduce transmission. The interaction between time of application and types of buttermilk was not significant.

The incubation period in all the treatments increased significantly than in control. It was slightly increased by 3.4, 3.8 and 3.9 days over control at 2, 3 and 4per cent concentrations, respectively. It increased by 2.5 and 6.0 days over control when buttermilk types applied before 24 hr, and application of inoculum mixed with casein respectively. The interaction between time of application and chemicals was significant. Hein (1975) reported that there was reduction in spread of carnation vein mottle virus when sprayed with skim milk + maize oil + Metasystox. In a field trial, Murthy and Nagarajan (1986) observed that 1per cent milk reduced the spread of TMV in tobacco.

*Effect of chemicals, plant and animal products under pot culture condition :*

The disease incidence recorded in relation to different treatments in the field is presented in Table 5. The data showed that DHT reduced the disease spread to the maximum extent (9.01per cent) compared to control (1.47per cent). However all the other materials tested were also effective in reducing the disease spread significantly over control. The interaction between days and treatments was non-significant.

Using DHT in field, Schuster and Hanzsch (1981) reduced spread of potato viruses. This chemical protected tobacco plants against PVX for prolonged period Schuster and Kramer, (1982). Combined application of DHT with ribavirin retarted multiplication of PVX in tobacco Schuster, (1982). Spraying of *Thuja*, plant extract and buttermilk also reduced the disease significantly over control. The reduction in disease due to these treatments and their probable mode of action has been discussed earlier.

Neem oil tested in this study reduced the disease incidence. The reduction in spread of the virus diseases by application of plant oils has been reported by several workers Singh and Varma, (1977); Sharma and Varma, (1982). Neem oil possesses an adverse effect on some vectors due to significant reduction in food intake by *N.*

Table 2: Effect of antiphytoviral chemicals on ULCV transmission by sap

| Chemicals | Percent infection of ULCV | | | | | Incubation period (days) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | Mean | A | B | C | D | Mean |
| DHT | 50.0 | 25.5 | 61.2 | 55.6 | 48.1 | 21.5 | 25.5 | 20.5 | 18.0 | 21.4 |
| | (44.98) | (27.80) | (51.46) | (48.22) | (43.07) | (4.61) | (5.06) | (4.06) | (4.24) | (4.64) |
| Acetyl Salisalic acid | 77.8 | 72.3 | 77.8 | 77.8 | 77.1 | 18.0 | 20.0 | 21.5 | 19.5 | 19.8 |
| | (62.15) | (58.43) | (62.15) | (62.11) | (61.18) | (4.24) | (4.47) | (4.61) | (4.43) | (4.44) |
| Salisalic acid | 61.2 | 72.3 | 72.3 | 61.2 | 80.1 | 20.5 | 20.5 | 18.0 | 18.0 | 19.3 |
| | (51.46) | (58.43) | (58.43) | (51.46) | (64.94) | (4.50) | (4.54) | (4.24) | (4.24) | (4.38) |
| Benzoic acid | 61.2 | 50.0 | 55.6 | 53.4 | 53.4 | 18.0 | 18.0 | 18.0 | 18.0 | 18.0 |
| | (51.46) | (44.98) | (48.22) | (48.22) | (46.67) | (4.24) | (4.24) | (4.24) | (4.24) | (4.24) |
| Carbendazim | 55.6 | 77.8 | 50.0 | 44.5 | 57.3 | 22.0 | 21.0 | 20.0 | 19.0 | 20.5 |
| | (48.22) | (62.15) | (44.97) | (41.73) | (49.22) | (4.68) | (4.58) | (4.47) | (4.35) | (4.52) |
| Thuja | 44.5 | 44.5 | 50.0 | 61.2 | 50.1 | 22.0 | 23.0 | 21.0 | 19.5 | 21.4 |
| | (41.73) | (41.73) | (44.97) | (51.46) | (44.98) | (4.68) | (4.78) | (4.58) | (4.43) | (4.58) |
| Control | 77.8 | | | | 77.8 | 18.0 | | | | 18.0 |
| | (62.15) | | | | (68.15) | (4.24) | | | | (4.24) |
| Mean | 54.25 | 52.25 | 48.2 | 60.25 | | 20.75 | 22.04 | 20.4 | 19.0 | |
| | (47.41) | (41.82) | (49.79) | (50.91) | | (4.14) | (4.71) | (4.04) | (4.35) | |

C.D. (P = 0.05)
Figures in parenthesis are arcsine transformed values

A = 24 hr before inoculation; B = 0 hr inoculation; C = 24 hr after inoculation; and D = 5 days after inoculation

| | | |
|---|---|---|
| Hours | NS | 0.07 |
| Chemicals | 5.42 | 0.08 |
| Hours x chemicals | 10.86 | 0.17 |

*virescence* in rice Mariappan and Saxena, (1983) due to antifeedant and repellant properties of neem oil. Varma (1974) identified two compounds viz., nimdin and nimbin in neem oil which inhibited local lesion formation. Coudriet *et al.*, (1985) reported that neem seed extract repelled whitefly from alighting on cotton. Thus, the field experiment has corroborated the results obtained from pot culture trials.

*Effect of barrier crops on disease spread :*

To select a suitable barrier crop to reduce the spread of the disease, a field trial was conducted and the observations revealed that all the three barrier crops to be equally effective in reducing the spread of the disease significantly over control (Table 6). The mean percentage of disease incidence was 3.17, 2.91 and 3.59 in maize, sorghum and pearl millet barriers respectively, whereas in control it was 6.39per cent. There were no significant differences among the treatments. The per cent disease increase was observed only up to 42 DAS. After that, there was no significant increase in disease incidence in plots with barrier crops. But the control plots recorded double the per cent incidence even after 42 DAS.

Thresh (1976) stated that incoming vectors tend to alight on the plants in the border forming edge effects. Singh (1985) reported that maximum protection by barrier will depend on many factors such as vigour, thickn and height of barriers, environmental factors like the v

Table 3 : Effect of buttermilk on ULCV transmission by sap

| Type of buttermilk | Percent infection of ULCV | | | | | Incubation period (days) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | Mean | A | B | C | D | Mean |
| Fresh | 44.5 | 22.3 | 44.5 | 66.7 | 44.8 | 17.5 | 22.5 | 18.5 | 16.5 | 18.8 |
| | (41.73) | (27.80) | (41.73) | (55.18) | (41.61) | (4.43) | (5.01) | (4.33) | (4.12) | (4.49) |
| 24 hr fermented | 55.6 | 44.5 | 55.6 | 66.7 | 55.4 | 19.5 | 24.8 | 17.5 | 16.5 | 19.6 |
| | (48.22) | (41.73) | (48.22) | (33.18) | (48.34) | (4.54) | (5.09) | (4.43) | (4.18) | (4.54) |
| 48 hr fermented | 44.5 | 50.0 | 44.5 | 83.4 | 55.6 | 20.5 | 26.6 | 17.5 | 17.0 | 20.4 |
| | (41.73) | (44.97) | (41.73) | (66.21) | (48.67) | (4.56) | (4.99) | (4.41) | (4.28) | (4.56) |
| Control | 83.4 | | | | 83.4 | 16.5 | | | | 16.5 |
| | (65.87) | | | | (65.87) | (4.12) | | | | (4.12) |
| Mean | 57.0 | 50.1 | 57.0 | 75.1 | | 18.5 | 22.5 | 17.5 | 16.6 | |
| | (49.39) | (45.0) | (49.0) | (64.25) | | (4.51) | (5.03) | (4.36) | (4.21) | |

C.D. (P = 0.05)

Figures in parenthesis are arcsine transformed values

A = 24 hr before inoculation; B = 0 hr inoculation; C = 24 hr after inoculation; and D = 5 days after inoculation

| | | |
|---|---|---|
| Hours | 7.18 | 0.06 |
| Buttermilk type | 6.21 | 0.05 |
| Hours x chemicals | NS | NS |

Table 4: Effect of casein on ULCV transmission by sap

| Concentration | Percent infection of ULCV | | | | | Incubation period (days) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | Mean | A | B | C | D | Mean |
| 2 | 83.4 | 44.5 | 77.8 | 88.9 | 73.7 | 19.8 | 25.0 | 15.0 | 17.5 | 20.1 |
| | (66.25) | (41.73) | (62.15) | (69.98) | (60.03) | (4.16) | (4.76) | (4.32) | (4.08) | (4.33) |
| 3 | 83.4 | 38.9 | 88.9 | 88.9 | 75.1 | 20.6 | 25.9 | 19.0 | 17.5 | 20.8 |
| | (66.25) | (38.49) | (69.98) | (69.98) | (61.17) | (4.43) | (4.96) | (4.32) | (4.08) | (4.42) |
| 4 | 77.8 | 44.5 | 88.9 | 88.9 | 75.1 | 20.6 | 25.0 | 19.5 | 18.8 | 20.9 |
| | (62.15) | (41.73) | (69.98) | (69.98) | (60.96) | (4.54) | (5.16) | (4.16) | (4.12) | (4.49) |
| Control | 88.9 | | | | 88.9 | 17.0 | | | | 17.0 |
| | (69.98) | | | | (69.98) | (4.08) | | | | (4.08) |
| Mean | 83.3 | 54.2 | 86.2 | 88.9 | | 19.5 | 23.0 | 18.6 | 17.7 | |
| | (64.89) | (40.65) | (67.37) | (69.98) | | (4.38) | (4.96) | (4.22) | (4.09) | |

C.D. (P = 0.05)

Figures in parenthesis are arcsine transformed values

A = 24 hr before inoculation; B = 0 hr inoculation; C = 24 hr after inoculation; and D = 5 days after inoculation

| | | |
|---|---|---|
| Hours | 7.84 | 0.06 |
| Buttermilk type | NS | 0.06 |
| Hours x chemicals | NS | 0.12 |

velocity, direction and growth of the crop. The low disease incidence noted in the present study in plots with barriers and snap beans reduced the incidence of pepper vein-banding mosaic virus and PVY in chillies in Florida.

Table 5: Effect of chemicals, plant extract and animal products on ULCV disease spread and yield

| Treatments | Percent disease incidence DAS | | | | | | |
|---|---|---|---|---|---|---|---|
| | 28 | 35 | 42 | 49 | 56 | Mean | Yield (kg/ha) |
| DHT | 0.09 (2.15) | 0.89 (5.38) | 1.07 (5.89) | 5.89 (14.01) | 9.01 (17.46) | 3.39 (8.98) | 876 |
| Thuja | 0.27 (3.01) | 1.07 (5.89) | 1.97 (8.01) | 6.52 (14.76) | 11.16 (19.49) | 4.19 (10.24) | 868 |
| *M. Jalapa* | 0.18 (2.58) | 0.81 (5.05) | 1.79 (7.63) | 6.43 (14.73) | 10.81 (19.25) | 4.01 (9.85) | 862 |
| Buttermilk | 0.09 (2.15) | 0.72 (4.76) | 1.43 (6.79) | 6.43 (15.63) | 10.45 (18.84) | 3.84 (9.43) | 860 |
| Neem oil | 0.26 (3.01) | 0.81 (5.11) | 1.34 (6.64) | 5.09 (12.77) | 11.51 (19.81) | 3.81 (9.47) | 864 |
| Control | 1.07 (6.64) | 1.63 (8.15) | 2.86 (10.88) | 9.20 (17.64) | 14.47 (22.35) | 5.85 (13.13) | 856 |
| Mean | 0.33 (3.25) | 0.99 (5.73) | 1.75 (7.64) | 6.59 (14.76) | 11.24 (19.53) | | |

C.D (P=0.05)
Figures in parenthesis are arcsine transformed values

Days = 0.49
Treatments = 0.54
Days x chemicals = NS

Table 6: Effect of barrier crops on disease incidence (per cent) and grain yield

| Barrier crops | DAS | | | | | Mean | Yield(kg/ha) | |
|---|---|---|---|---|---|---|---|---|
| | 28 | 35 | 42 | 49 | 56 | | Urd bean | Barrier crops |
| Maize *(Zea mays)* | 1.43 (6.67) | 2.50 (8.96) | 3.43 (10.53 | 4.14 (11.62) | 4.28 (11.83) | 3.17 (9.92) | 626 | 514 |
| Sorghum *(Sorghum bicolor)* | 1.22 (6.16) | 2.22 (8.44) | 3.22 (10.22) | 3.93 (11.33) | 3.93 (11.33) | 2.91 (9.49) | 638 | 486 |
| Pearl millet *(Pennisetum americanum)* | 1.22 (6.21) | 2.64 (9.34) | 3.86 (11.28) | 5.07 (12.98) | 5.14 (13.16) | 3.59 (10.59) | 658 | 322 |
| Control | 1.07 (5.83) | 2.64 (9.33) | 4.07 (11.63) | 10.86 (19.02) | 13.32 (21.18) | 6.39 (13.39) | 822 | -- |
| Mean | 1.24 (6.22) | 2.50 (9.02) | 3.65 (10.92) | 6.00 (13.74) | 6.67 (14.37) | | | |

C.D. (P = 0.05)
Figures in parenthesis are arcsine transformed values

Days = 0.76
Crops = 0.68
Days x crops = 1.52

can be attributed to the faster growth of the barrier crops than urd bean in early stages, which might have prevented the vector landing on the main crop.

The reduction in disease spread due to barrier crops has been reported by several workers. Simons (1957, 1960) found that the use of barrier crops like sunflower Similarly in Punjab, Deol and Rataul (1978) reported that the use of barrier crops, viz., sunflower, gingelly, sorghum and pearl millet reduced the spread of CMV in chilli and also increased the yield over control. From the present study it can be concluded that barrier crops offer an effective solution in reducing spread of the virus. In this connection,