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Non-pesticidal management of golden mosaic virus disease of cowpea (*Vigna unguiculata* L.): An ecofriendly approach in changing climate

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Abstract
The present investigation was carried out to evaluate the effect of different trap crops *viz.*, Cluster bean (Guar), pearl millet (Bajra), sorghum (Jowar) and sesame (Til) and different mulches *viz.*, sawdust, straw mulch, yellow and greyish blue polyethylene on disease severity, vector population and grain yield as an ecofriendly alternative approaches of chemicals under field condition against golden mosaic virus disease of cowpea. The results revealed that cluster bean sown as the trap crop was observed to be the best for reducing per cent disease intensity (56.93%), vector population (5.86 per plant) and increasing seed yield (84.23%). Out of four mulches, yellow polyethylene was found most effective in reducing per cent disease intensity (82.81%), vector population (2.33 per plant) and increasing seed yield (79.45%).

Keywords: Cowpea, golden mosaic disease, trap crop, mulches, disease severity, grain yield loss

Introduction
Cowpea (*Vigna unguiculata* Linn., 2n = 22) is an annual tropical grain legume crops grown by resource poor farmers in the developing countries of the tropics and subtropics, especially in sub Saharan Africa, Asia Central and South America due to its social, economic and dietary importance. The cowpea seeds are highly nutritious with dried grain containing up to 25% protein and 56% carbohydrate and vitamins for man, feed for animals, and also a source of cash income. Cowpea leaves and green pods are consumed as vegetable and the dried grain is used in many different food preparations (Kyei-Boahen *et al.*, 2017) [8].

Cowpea is an essential component of the cropping systems because it fixes atmospheric nitrogen and contributes to soil fertility improvement particularly in smallholder farming systems where little or no fertilizer is used (Kyei-Boahen *et al.*, 2017) [8]. In India, this crop is cultivated in two different seasons' *viz.*, Summer (March-June) and *kharif* (July-Oct.) in arid and semi-arid tracts of Rajasthan, Karnataka, Kerala, Tamil Nadu, Maharashtra, Madhya Pradesh, Andhra Pradesh and Gujarat. The maximum area of its cultivation is under *Kharif*, where it forms a key component of the cropping system due to its importance and intercropping with sorghum, pearl-millet, maize, cotton, castor, pigeon pea etc. are popular (Jayappa *et al.*, 2017) [3].

In spite of its importance, cowpea faces numerous production constraints. The major constraints in cowpea production are low yields of traditional varieties, and high susceptibility to viral, fungal and insect damage. Significant proportion of losses is due to virus infection which is estimated between 10 and 100% (Kareem K.T. and Taiwo M.A. (2007), depending on the virus-host vector relationships as well as the prevailing epidemiological factors. Cowpea plants are often infected by more than one virus, resulting in serious economic losses in its production (Byoung-Cheorl, 2005) [1].

Cowpea is highly susceptible to golden mosaic disease (Varma and Reddy, 1984) [13]. CGMD was earlier confined only to northern India (Varma and Malathi, 2003) [12] and was believed to be caused by a whitefly-transmitted Geminivirus distinct from the YMVs infecting mungbean and blackgram, MYMV and MYMIV (Varma and Reddy, 1984) [13]. Among these diseases, golden mosaic of cowpea is most important and destructive. This disease caused by Mungbean Yellow Mosaic India Virus and transmitted by white fly (*Bemisia tabaci*). Although the effective control of disease can be only possible through management aspects. However, chemical applications cause hazards to human health and increase environmental pollution. Therefore, alternative ecofriendly approaches for control of disease are needed.

Materials and Methods
Experimental site
The present investigation was carried out during *Kharif* 2020-2021 at the Agronomy Farm, S.K.N. College of Agriculture, Jobner, Department of Plant Pathology, S.K.N. College of Agriculture (Sri Karan Narendra Agriculture University), Jobner, Rajasthan. Jobner is situated at latitude 26° 5' N, longitude of 75°2°' E and altitude of 427 meters above MSL (mean sea level). The region falls under semi-arid eastern plain (Agro Climatic Zone- lll A) of Rajasthan.

Raising of crop
The field was prepared before sowing by cross ploughing with tractor drawn disc harrow and planked. The field experiment was conducted on susceptible Cowpea variety RC-19. The lay out plans of field experiment was demarcated in the field for treatment application. The crop was sown in the second week of July except date of sowing experiment. The crop was raised in plots of 3 x 2 m keeping row-to-row and plant-to-plant distance of 40 x 15 cm. The irrigation, weeding and hoeing were applied as per the recommendation for the crop in this zone. For keeping desired plant populations, thinning was done.

Effect of different trap crops on disease severity, vector population and grain yield
The experiment was conducted in randomized block design with four replications. Cluster bean (Guar), pearl millet (Bajra), sorghum (Jowar) and sesame (Til) were used as trap crops. Observations for disease intensity recorded near crop maturity and for grain yield at physiological maturity. Assessment of virus symptoms in cowpea was based on occurrence and symptom severity. Disease severity was assessed on cowpea leaves with occurrence of viral symptoms and it was performed visually based on the following standard rating scale: where 1 = 0% (absence of viral disease symptoms) and whenever the index 5 ≥ 60% (very severe symptoms leads to death of the plants). Infected plants exhibiting stunted growth, severe leaf curling, reduced leaf size, yellow patches and distortion of leaf lamina symptoms were selected for sampling (Plate -1). Per cent disease intensity was calculated as described under.
Per cent disease index was calculated by scoring disease as per disease rating scale of 0 – 5 and using following formula suggested by Mc Kinney (1923) [9].

$$PDI = \frac{\text{Sum of all numerical ratings}}{\text{Number of plants assessed x Maximum disease rating}} \times 100$$

Effect of different mulches on disease severity, vector population and grain yield
The experiment was conducted in randomized block design in 3 × 2 m plot at a spacing of 40 × 15 cm with four replications. Sawdust, straw mulch, yellow and greyish blue polyethylene were used as mulches. Observations for disease intensity recorded near crop maturity and for grain yield at physiological maturity. Assessment of virus symptoms in cowpea was based on occurrence and symptom severity. Disease severity was assessed on cowpea leaves with occurrence of viral symptoms and it was performed visually based on the following standard rating scale: where 1 = 0% (absence of viral disease symptoms) and whenever the index 5 ≥ 60% (very severe symptoms leads to death of the plants). Infected plants exhibiting stunted growth, severe leaf curling, reduced leaf size, yellow patches and distortion of leaf lamina symptoms were selected for sampling (Plate -2). Per cent disease intensity was calculated as described at under.
Per cent disease index was calculated by scoring disease as per disease rating scale of 0 – 5 and using following formula suggested by Mc Kinney (1923) [9].

$$PDI = \frac{\text{Sum of all numerical ratings}}{\text{Number of plants assessed x Maximum disease rating}} \times 100$$

Estimation of yield loss due to Golden mosaic of cowpea
Plants showing yellow mosaic symptoms were tagged after 20 days of sowing and subsequently after 10 days intervals till harvesting stage so as to include plants showing various disease intensity categories. At the time of harvest, tagged plants were randomly selected in each category. Data on yield contributory characters such as number of pods, seeds per pod, 1000 grain weight (test weight) and grain yield were recorded and the per cent loss in yield was calculated by the following formula described by Nene (1972).

$$Q = \frac{a - b}{a} \times 100$$

Where
Q = Per cent yield loss
a = Average yield from a healthy plant
b = Average yield from a diseased plant

At the time of harvest, 3 tagged plants were randomly selected from each replication in each category. Plants were observed for number of pods, seeds per pod, 1000 grain weight (test weight) and grain yield. Golden mosaic of cowpea is one of the major important disease causing considerable yield loss. Effect of trap crops and different mulches, on the intensity of cowpea golden mosaic and yield per plot was investigated with an objective to find out the suitable package of efficient management of the disease. The data were obtained for statistically analysis.

Results
Effect of trap crops on disease severity
Effect of different trap crops was studied on the intensity of the golden mosaic and grain yield per hectare. The per cent disease intensity varied significantly among the different trap crops (Table 1, Fig. 1 and Plate-1). Minimum disease intensity (21.51%) was recorded when cluster bean was used as a trap crop with 56.93 per cent decreased intensity. The intensity was highest (34.51%) when sesame was sown as a trap crop followed by pearl millet (32.61%) sown as trap crops.

Plate 1: Field trial on effect of trap crops on Golden Mosaic Disease development, 1- Cluster bean 2- Pear millet 3- Sorghum 4- Sesame

Table 1: Effect of trap crop on disease intenaity of EGMV of cowpea

S.No.	Trap crop	*Per cent disease intensity	White fly population/ mung bean plant	Decrease in PDI over control (%)
1	Cluster bean	21.51 (27.63)	5.86	56.93
2	Pearl millet	32.61 (34.82)	8.74	34.71
3	Sorghum	29.87 (33.13)	8.42	40.20
4	Sesame	34.51 (35.98)	12.95	30.91
5	Control	49.95 (44.97)	19.42	-
	SEm±	1.42		
	CD (P=0.05)	4.36		
	CV (%)	6.42		

* Average of four replications
Angular transformed value given in parenthesis

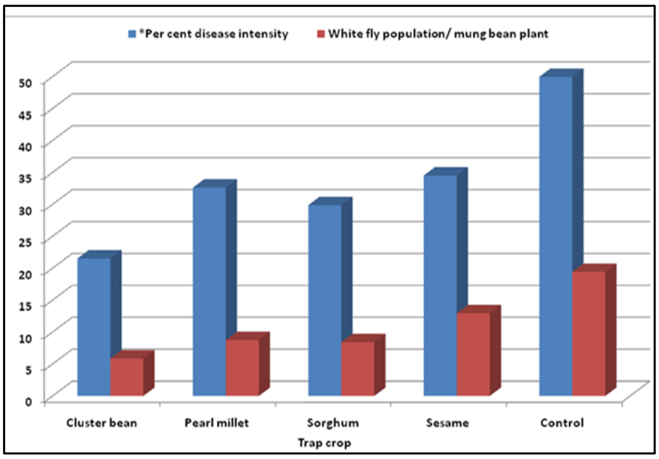

Fig 1: Effect of trap crops on the disease intensity, white fly population/plant infected by Cowpea Golden Mosaic Virus

Effect of trap crops on vector population

The effect of trap crop was investigated on the vector (*Bemisia tabaci*) population per plant to obtain additional information to support the results obtained on the incidence of the mosaic virus. It was observed (Table 1, Fig. 1 and Plate-1) that maximum vector population was in sesame used as trap crop (12.95 whiteflies/plant) followed by pearl millet (8.74 whiteflies/plant). Minimum vector population was in cluster bean used as trap crop (5.86 whiteflies/plant).

Effect of trap crops on grain yield

The grain yield per hectare obtained also had significant differences between the trap crops (Table 2, Fig. 2 and Plate-1). The yield was higher in the treatments as compared to the control. The yield was highest when cluster bean was used as trap crop (7.43 q/ha) with increased grain yield (84.23%) over control followed by sorghum (6.65 q/ha and 63.79%), respectively. Grain yield of sorghum and pearl millet treatments was found at par 6.65 and 6.25 q/ha. It is obvious from the data that the intensity of the disease and yield were inversely related over the different trap crops. From the results obtained (Table 2, Fig. 2 and Plate-1) on the golden mosaic intensity and yield per hectare, it can be concluded that cluster bean sown as trap crop is the best for the cowpea crop, for reducing the incidence of golden mosaic and increasing the grain yield.

Table 2: Effect of trap crop on the grain yield of CGMV affected cowpea

S.No.	Trap crop	*PDI	*Yield (g/plot)	*Yield (q/ha)	Increase yield over control
1	Cluster bean	21.51 (27.63)	448.85	7.43 (15.82)	84.23
2	Pearl millet	32.61 (34.82)	375.10	6.25 (14.48)	53.94
3	Sorghum	29.87 (33.13)	399.55	6.65 (14.94)	63.79
4	Sesame	34.51 (35.98)	338.75	5.64 (13.74)	38.91
5	Control	49.95 (44.97)	343.95	4.06 (11.62)	-
SEm±		1.42	16.97	0.64	
CD (P=0.05)		4.36	52.29	1.96	
		6.42	7.12	7.20	

* Average of four replications
Angular transformed value given in parenthesis

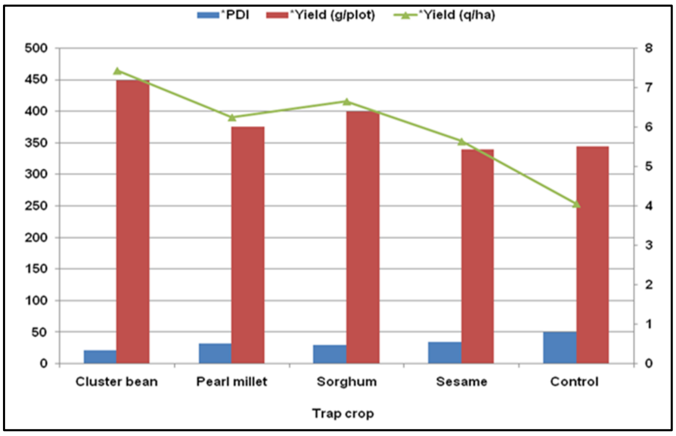

Fig 2: Effect of trap crops on the per sent disease intensity and grain yield infected by Cowpea Golden Mosaic Virus

Effect of different mulches on disease severity

Effect of the four different mulches namely saw dust, yellow polyethylene, greyish blue polyethylene, and wheat straw were studied on the intensity of golden mosaic, yield per hectare and vector population/plant. The statistical analysis of the data showed that the all treatments (including control) have significant differences in the disease intensity, yield as well as vector population on the plant.

For the disease intensity, use of yellow polyethylene was the best treatment, reducing the intensity to a minimum of 8.91 per cent as against the intensity of 51.85 per cent recorded in the control. This was followed by wheat straw mulch (14.17%) and greyish blue polyethylene mulch (18.87%) **(**Table 3, Fig. 3 and Plate-2).

Minimum disease intensity (8.91%) was recorded when yellow polyethylene mulch was used with 82.81 per cent decreased intensity. The intensity was highest (23.53%) when saw dust was used as mulch followed by grey polyethylene mulch (18.87%).

Plate 2: Field trial on effect of mulches on Golden Mosaic Disease development, 1- Saw dust 2- Straw 3- Yellow polyethylene 4- Greyish blue polyethylene

Table 3: Effect of mulches on the disease intensity of CGMV of cowpea

S.No.	Mulches	*Per cent disease intensity*	White fly population/ plant	Decrease in PDI over control
1	Saw dust	23.53	11.44	54.61
		(29.02)		
2	Wheat straw	14.17	5.08	72.67
		(22.11)		
3	Yellow Polyethylene	8.91	2.33	82.81
		(17.37)		
4	Geyishblue Polyethylene	18.87	8.52	63.61
		(25.75)		
5	Control	51.85	21.66	-
		(46.06)		
	SEm±	1.11		
	CD (P=0.05)	3.42		
	CV (%)	6.33		

* Average of four replications

Angular transformed value given in parenthesis

Effect of different mulches on vector population

The effect of mulches was investigated on the vector (*Bemesia tabaci* Genn.) population per plant to obtain additional information to support the results obtained on the incidence of the golden mosaic virus. It was observed that maximum vector population was in saw dust mulch (11.44 whiteflies/plant) and minimum in yellow polyethylene mulch (2.33 whiteflies/plant) followed by wheat straw (5.08/plant) (Table 3, Fig. 3 and Plate-2).

Effect of different mulches on grain yield

The grain yield per hectare was also significantly high in all the treatments as compared to the control (3.99 q/ha). The treatments, however, also had significant differences. The yield was highest in the use of yellow polyethylene mulch (7.16 q/ha) with increased grain yield (79.45%) over control followed by wheat straw mulch (6.71 q/ha and 68.17%), respectively. The other two mulches i.e. greyish blue polyethylene and saw dust though gave higher yield than the control, yet the yield levels were not much different from the control and were significantly lower than the other treatments (Table 4, Fig. 4 and Plate-2).

Table 4: Effect of mulches on the grain of CGMV affected cowpea

S.No.	Mulches	*PDI	*Yield (g/plot)	*Yield (q/ha)	Increase in yield over control (%)
1	Saw dust	23.53	341.95	5.70	42.85
		(29.02)		(13.81)	
2	Wheat straw	14.17	402.59	6.71	68.17
		(22.11)		(15.01)	
3	Yellow polyethylene	8.91	429.95	7.165	79.45
		(17.37)		(15.52)	
4	Greyish blue polyethylene	18.87	374.25	6.24	56.39
		(25.75)		(14.47)	
5	Control	51.85	239.55	3.99	-
		(46.06)		(11.52)	
	SEm±	1.11	16.65	0.63	
	CD (P=0.05)	3.42	51.28	1.94	
	CV (%)	6.33	7.45	7.17	

* Average of four replications

Angular transformed value given in parenthesis

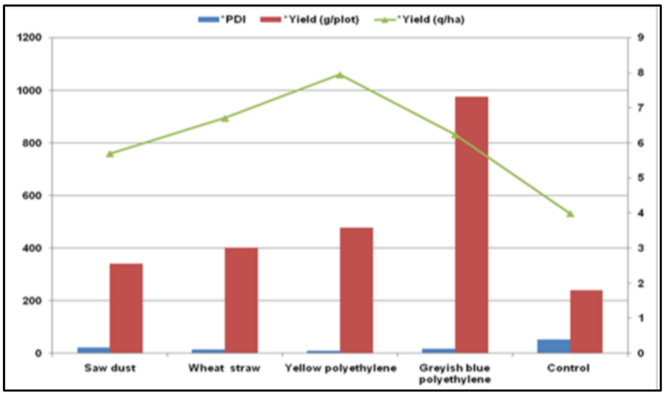

Fig 4: Effect of mulches on the per sent disease intensity and grain yield infected by Cowpea Golden Mosaic Virus

Discussion

Cowpea, (*Vigna unugiculata* L.), being extremely drought resistant crop is extensively cultivated in arid areas of

Rajasthan during *Kharif*. Golden mosaic of cowpea has been a limiting factor in its production. The disease was so severe in certain parts that cultivators even did not think of harvesting the crop. In view of economic importance of the disease and limited information available on yield loss and non pesticidal disease management, studies were carried out on present aspects of the disease management through use of different mulches and different trap crops.

Effect of different trap crops on disease severity, vector population and grain yield

The use of non-host crop in interpolating's and as a barrier crops can significantly reduce the virus spread in the field. In the present investigations it was observed that percent disease intensity and yield varied significantly among the treatments with different trap crops. A tall cover crop protects an undercover crop from insect borne viruses. The lowest per cent disease intensity (21.51%), minimum vector population (5.86 per plant), maximum disease control (56.93%) with increased seed yield (84.23%) was observed when cluster bean was sown as trap crop. Similar results of different trap crops have been reported elsewhere on disease severity, vector population and losses in grain yield of legumes affected by viral diseases by Raghupathi and Sabitha (1994) [11]; Kapoor (2012) [4]; Jat K (2018) [2]; and Kumar and Prasad (2020) [7].

Effect of different mulches on disease severity, vector population and grain yield

Knowledge about visual stimuli such as yellow traps used for catching insect has now been applied to field protection in the form of reflective mulches that partially or completely cover the soil. The mulches used are either attractive or repellent. Results of the experiments to compare the efficacy of different mulches for the exclusion of the vector by netting and control of the vector by the insecticides, showed that all the treatments have significant differences in the disease incidence, yield/plot, as well as vector population per plant, maximum grain yield and low vector population as compare to control. Out of the four mulches, the yellow polyethylene mulch and wheat straw mulch were better than grayish blue polyethylene mulch and saw dust mulch as for as yield/ha and vector population per plant are concerned. The lowest per cent disease intensity (8.91%), minimum vector population (2.33 per plant), maximum disease control (82.81%) with increased seed yield (79.45%) was observed when yellow polyethylene was used as mulching. Our results are in agreement with Khan and Mukhopadhyay (1985) [6]; Kapoor (2012) [4]; and Jat K (2018) [2].

Conclusion

We can conclude that MYMIV is serious problem in this crop during kharif 2020-21. As a result, Cluster bean as trap crop was found most effective against golden mosaic disease. There was significant increase in the per cent disease control (56.93%), increased seed yield (84.23%) with minimum vector population (5.86 per plant) of cowpea when sesame trap crop was recorded least effective. Out of four mulches, yellow polyethylene was found to be better in reducing the disease (82.81%) and increasing seed yield (79.45%) with minimum vector population (2.33 per plant). Saw dust was found least effective.

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