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Management of Cotton leaf Curl Virus by planting time and plant spacing

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Abstract. Cotton leaf curl virus (CLCuV) is one of the most destructive diseases limiting the vegetative growth and production of cotton. Development of CLCuV resistant cotton genotypes is the most effective strategy to minimize the yield losses due to this disease. But so far no cotton genotype resistant to CLCuV (Burewala strain) has been reported. We are then only left with the option to alter the management practices to minimize the yield losses. The objective of this study was therefore to determine the effects of planting time, plant spacing and genotypes on CLCuV incidence. Significant differences existed for seed cotton yield and its components and CLCuV infestation due to planting time and genotypes. Infestation due to CLCuV varied significantly among genotypes. Maximum seed cotton yield (2068kg/ha) was recorded in genotype MNH-6070 planted at 30the June with plant-to-plant spacing of 15cm. Moreover MNH-6070 proved to be better under CLCuV infestation than the rest. There was less disease incidence on 1st May planted cotton as compared to late sown cotton (15th & 30th June). Maximum CLCuV incidence was recorded within 30-45 days in late planting as compared to 105 days of early planted cotton. From the present study it is concluded that early planting with increased plant spacing and late planting with reduced plant spacing is effective in managing CLCuV to achieve optimum seed cotton yield.
Key Words: CLCuV, cotton, plant spacing, planting time, management.

Rezumat. Virusul frunzei creţe de bumbac, Cotton Leaf Curl Virus (CLCuV) este una din cele mai păgubitoare boli care limitează creşterea, dezvoltarea şi producţia de bumbac. Crearea genotipurilor de bumbac rezistente la CLCuV ar fi cea mai eficientă strategie pentru a minimiza pierderile de producţie cauzate de această boală, dar până acum nici un genotip de bumbac rezistent la CLCuV (linia Burewala) nu a fost găsit. Astfel, ne rămâne doar varianta de a manipula tehnicile de cultivare pentru a minimiza pierderile. Obiectivele acestui studiu au fost aşadar să determine efectele variaţiei epocii de plantare, a distanţei de plantare şi ale genotipului asupra incidenţei CLCuV. Diferenţe semnificative s-au constatat în cazul recoltelor de bumbac şi infestarea CLCuV în timpul epocii de plantare per varii genotipuri. Infestarea datorată CLCuV a variat semnificativ datorită diverselor genotipuri. Maximum de recoltă (2068kg/ha) s-a înregistrat la genotipul MNH-6070 plantat la 30 iunie, distanţa dintre plante fiind de 15cm. Astfel MNH-6070 s-a dovedit a fi mai productiv în condiţiile infecţiei cu CLCuV decât celelalte soiuri. S-a constatat şi o incidenţă mai redusă la bumbacul plantat la data de 1 mai, comparată cu cel semănat mai târziu (la 15 sau 30 iunie). Maximum incidenţei de CLCuV s-a înregistrat între 30-45 de zile de la data plantării mai târzii, comparativ cu 105 zile după plantare, la cel plantat mai devreme. Din acest studiu se poate trage concluzia că plantarea timpurie şi mărirea distanţei dintre plante cât şi plantarea târzie şi reducerea distanţei dintre plante sunt eficiente în prevenirea CLCuV pentru a obţine recolte de bumac cât mai bune.
Cuvinte cheie: CLCuV, bumbac, distanţă de plantare, epoca de plantare, management.

Introduction. Cotton leaf curl virus (CLCuV) is a disease of cotton (*Gossypium* spp.) caused by the leaf curl virus, which is transmitted through white fly *Bemisia* germ (EL-Nur, 1967) and belong to the genus, *Begonovirus* (Family *Geminiviridae*), Gemini virus subgroup III (Hameed et al 1994). The symptoms of disease include upward curling of leaf margins, thickening of veins which is pronounced on the lower surface of leaves and formation of minute foliar out growth called "enations". The affected veins appear abnormally dark green and opaque on the under surface (Watkins 1981). Cotton leaf curl virus disease was first reported in 1967 (El-Nur 1967). In 1992-1993, the disease appeared in epidemic form which caused decrease in cotton yield (Mahmoud 1999).

In 2001 a new race of CLCuV appeared in the Vehari District, and all the commercial varieties that were resistant to CLCuV fell prey to the new race of CLCuV (Tariq & Adress 2003). The results of Mansoor et al (2003) strongly suggest the emergence of resistance-breeding strain of CLCuV in Pakistan. The cotton crop faced a new threat with the emergence of new strain of CLCuV called Burewala strain, as all the genotypes and varieties of upland cotton present in Pakistan (CCRI, Multan, NIAB, NIBGE, Faisalabad, NIA, TandoJam, CCRI, Sakrand, CRI, Faisalabad and CRS, Multan etc) are susceptible to this variant of virus. The available genepool and source parents for resistance used in previous CLCuV resistant genotype found susceptible to new variant of CLCuV (Tariq & Adress 2003). There are two options to solve this problem.

a) To develop genetically resistant varieties to CLCuV B. Wala;
b) Management practices to minimize losses, due to CLCuV infestation.

The CLCuV affected plants showed stunted growth, less number of balls, reduction in ball size and deterioration in fiber quality in upland cotton (Tanveer & Mirza 1996).

Planting time has significant effect on seed cotton yield and its components. Among the yield components, number of balls per plant reduced from 32 to 07 from 1st May to 30th June of planting respectively. While ball weight reduced form 3.37 to 3.06gm for 1st May to 30th June of planting cotton respectively (Annual summary progress report Central Cotton Research Institute (OIC centre of excellence in Asia) Multan, 2008-2009 pp.17). The cause of reduction in seed cotton yield and its components is only due to planting time but also due to CLCuV has significant impact on it. Incidence of CLCuV was recorded maximum (100%) on 30th June's planting followed by 15th June at 30 days after planting, while 88% disease incidence was recorded after 120 days of 1st May of planted cotton (Annual summary progress report Central Cotton Research Institute (OIC centre of excellence in Asia) Multan, 2008-2009). The genotypes that were severely affected by CLCuV can be managed with increasing plant population and nitrogen fertilizer to achieve optimum seed cotton yield (Iqbal et al 2008). The objective of this study was therefore to find out the impact of different planting time and plant spacing for management of CLCuV and improvement of above mentioned traits.

Material and Method. A field experiment was conducted during 2007-2008 at Cotton Research Station (CRS) Multan to evaluate the impact of planting time and plant spacing on seed cotton yield and its components and CLCuV incidence. Three cotton genotypes were selected on the basis of CLCuV susceptibility. The detail of few traits of three varieties is as follows in Table 1.

Table 1

The three varieties of cotton selected on the basis of CLCuV susceptibility

Sr.#	*Variety*	*CLCuV*	*B/P*	*GOT %*
V1	MNH-6070*	0.3	3.1	41.8
V2	MNH-738**	11	3.8	38.0
V3	CIM-496	90	3.4	36.2

*= Iqbal et al.2008, **= Approval case of MNH-738 by CRS Multan.

Prior to planting, the field was disked and rotavated before using the bed shaper to prepare flat- top ridges. The detail of treatments is as follows:

1. Planting time = 1st May (D1), 15th May (D2), 30th May (D3), 15th June (D4) and 30th June (D5);
2. Plant Spacing = PxP= 15cm (S1), 30cm (S2) and 45cm (S3);
3. Genotype = V1 (MNH-6070), V2 (MNH-738) and V3 (CIM-496).

Treatments were arranged in split plot randomized complete block design, keeping the sowing date in main plot, plant spacing in sub plot and genotypes in sub-sub plot. Sowing

was done by dibbling method. All other cultural practices were performed in standard fashion to optimize the seed cotton yield. Data were collected for the following traits:

1. Monopodial branches/plant
2. Sympodial branches/plant
3. Number of bolls/plant
4. Boll weight (gm)
5. Seed cotton yield (Kg/ha)
6. Ginning outturn (GOT %)
7. Cotton leaf curl virus (CLCuV %) (based on total plant population of plot in 15th August, 2007).

CLCuV % on genotypes planted at different date was recorded fortnightly and data for statistical analysis of CLCuV% was recorded on 15th August. In our experiment, the plot size of sub-sub plot was four rows of 10 m long. Plots were harvested at maturity for seed cotton yield and GOT %. Data for monopodial branches/plant, sympodial branches/plant were recorded from ten guarded plants of central two rows, while boll weight was recorded by picking and counting the bolls from five plants. All the fiber traits were analyzed by HVI (High Volume Instrument by Uster).

The data were subjected to analysis of variance using the computer program M-Stat C. Means were separated using Fisher's protected Least Significant Difference (LSD) test.

In all statistical tests, significance was determined at P=0.05%. Interaction between planting time, plant spacing and genotypes for each variable was measured.

Results and Discussion. From analysis of variance (Table 2), it is evident that effect due to planting time is significant for monopodial branches/plant, sympodial branches/plant, number of balls/plant, seed cotton yield and CLCuV. Plant spacing had significant effect on monopodial branches/plant, sympodial branches/plant, number of balls/plant, boll weight and seed cotton yield. The interaction of planting time and plant spacing was significant for monopodial branches/plant, sympodial branches/plant, number of balls/plant, ball weight, seed cotton yield and CLCuV. The genotypes had significant effect on all the traits under study. Similarly the interaction of genotype with planting time and plant spacing was also significant for all the traits under study except the CLCuV for genotype and plant spacing interaction. CLCuV is one of the destructive diseases of cotton (Nelson et al 1998). At present all the genotypes of *Gossypium hirsutum* L. are susceptible to CLCuV, but this susceptibility varies with the genotypes.

Maximum CLCuV was recorded on all genotypes planted on 30th June followed by 15th June at 45 and 60 days after planting respectively. All genotypes fell pray to disease during last week of July. However there was less disease incidence on 1st May planted cotton compared to other planting dates. The genotype MNH-6070 had less attack of CLCuV than other genotypes during 1st May, 15th June and 30th June (Table 10). Similar findings have been reported by plant pathologists of Central Cotton Research Institute (CCRI) Multan in annual progress report 2008. Significant differences for CLCuV existed for planting time. Early planting had low infestation as compared to late sown cotton (D5). CLCuV infestation percentage reached maximum within 50-60 days in late sown cotton while the maximum infestation in early sown cotton was recorded after 100 days of sowing (Tables 3, 9 and 10). The significant differences among the genotypes for CLCuV were due to their different genetic constitution. The genotype MNH-6070 showed higher resistance to CLCuV infestation as compared to CIM-496 and MNH-738 (Table 5). The interaction among planting time, plant spacing and genotype was significant for CLCuV, seed cotton yield and its components (Table 2 and 9). This significant difference leads us to conclude that planting time, plant spacing and genotype had significant impact seed cotton yield and yield component traits which were improved by increasing plant spacing in early sown cotton while late planting (D4 and D5), these yield components reduced significantly (Table 4, 6 and 9).

Seed cotton yield was higher in early planting with high plant spacing (S3) while maximum yield was recorded at low plant spacing (Table 3, 4 and 9). Similar findings have been reported by Tanveer & Mirza (1996) and James et al (2004). CLCuV

infestation is affected by genetic constitution of variety but did not affect by plant spacing. CLCuV has a significant impact on seed cotton yield and its components as the plant is stunted, number of balls/plant and ball weight reduced significantly (Tanveer & Mirza 1996; Brown 2001). Therefore the major cause of decrease in seed cotton yield is not just the late planting but also the CLCuV infestation. The higher level of CLCuV infestation at early stage of cotton growth reduce monopodial branches/plant, sympodial branches/plant, number of balls/plant, and ball weight which ultimately reduce seed cotton yield (Table 9). Similar findings have been reported by (Tahir & Mehmood 2005). Maximum seed cotton yield in late planting (D4 and D5) was recorded under low plant spacing (Table 9). This impact of plant spacing in late sown cotton might be due to early stunted growth of plant due to CLCuV infestation.

Table 2

Mean squares of analysis of variance for monopodial branches/plant, sympodial branches/plant, number of balls/plant, ball weight, seed cotton yield and CLCuV

SOV	*Df*	*MNO*	*SYMP*	*B/P*	*Ball Weight (gm)*	*Yield Kg/ha*	*GOT %*	*CLCuV*
Replications	2	0.107^{NS}	4.896 ^{NS}	68.289*	0.003 ^{NS}	188986.06*	0.353 ^{NS}	5.045 ^{NS}
SD	4	3.891*	1466.585*	1225.3*	0.231 ^{NS}	17401503.9*	9.924*	15651.16*
Error a	8	0.045	1.480	2.557	0.104	2613.372	0.162	2.254
S	2	3.371*	94.719*	5565.62*	0.068*	60424.067*	0.099 ^{NS}	5.4^{NS}
SD x S	8	0.161*	6.609*	92.03*	0.020 ^{NS}	422987.56*	0.319 ^{NS}	3.999^{NS}
Error b	20	0.022	0.974	3.248	0.011	4014.011	0.037	3.2
V	2	17.646*	273.607*	928.067*	0.430*	4851292.4*	69.239*	10527.65*
SD x V	8	0.675*	15.469*	70.585*	0.016*	468924.38*	0.857*	951.695*
S x V	4	0.804*	2.641*	41.756*	0.003 ^{NS}	13875.4*	0.187*	0.548^{NS}
SD x S x V	16	0.156*	4.057*	14.135*	0.007 ^{NS}	34124.775*	0.407*	3.442*
Error c	60	0.037	1.270	1.022	0.005	15113.767	0.028	0.532

Note: * = significant at 0.05 %, NS = non significant.
SD= sowing date, S= Plant spacing, V= Genotypes, MNO= monopodial branches/plant, SYMP= sympodial branches/plant, B/P= number of balls/plant.

Table 3

Effect of sowing date on monopodial branches/plant, sympodial branches/plant, number of balls/plant, ball weight, seed cotton yield and CLCuV

	MNO	*SYMP*	*B/P*	*Boll Weight*	*Yield Kg/ha*	*GOT*	*CLCuV*
D1	1.35	26.85	33.51	3.27	4328.3	38.94	3.26
D2	1.19	27.29	34.74	3.29	3991.4	39.44	4.10
D3	0.82	21.74	29.18	3.30	3334.4	39.84	29.00
D4	0.65	13.00	23.70	3.36	2090.5	40.20	43.10
D5	0.43	11.92	18.70	3.12	1274.6	40.46	63.31

Table 4

Effect of spacing on monopodial branches/plant, sympodial branches/plant, number of balls/plant, ball weight, seed cotton yield and fiber traits

	MNO	*SYMP*	*B/P*	*Ball Weight*	*Yield Kg/ha*	*GOT*	*CLCuV*
S1	0.59	21.46	15.44	3.24	3514.2	39.82	26.09
S2	0.96	20.42	31.82	3.38	3414.1	39.78	28.05
S3	1.12	18.60	36.66	3.18	3283.2	39.73	27.74

Table 5

Effect of genotypes on monopodial branches/plant, sympodial branches/plant, number of balls/plant, ball weight, seed cotton yield and CLCuV

	MNO	*SYMP*	*B/P*	*Ball Weight*	*Yield Kg/ha*	*GOT*	*CLCuV*
V1	0.48	21.16	28.29	3.23	3559.7	40.88	14.38
V2	0.59	21.98	32.35	3.38	3625.2	38.43	23.31
V3	1.61	17.35	23.29	3.19	3026.6	40.02	44.19

Table 6

Mean performance under interaction of sowing date and plant spacing for different traits

	MNO	*SYMP*	*B/P*	*Boll Weight*	*Yield Kg/ha*	*GOT*	*CLCuV*
D1S1	0.83	27.22	18.56	3.29	4116.1	39.15	3.19
D1S2	1.52	27.44	37.22	3.31	4321.5	39.03	2.46
D1S3	1.71	25.89	44.78	3.21	4547.2	38.62	3.15
D2S1	0.82	28.12	18.78	3.25	3982.9	39.51	8.48
D2S2	1.31	27.45	39.11	3.36	4023.3	39.42	10.09
D2S3	1.46	26.34	46.32	3.27	3968.1	39.40	10.82
D3S1	0.56	23.89	15.67	3.26	3618.1	39.98	20.17
D3S2	0.88	21.78	33.77	3.34	3315.8	39.78	22.94
D3S3	1.04	19.56	38.10	3.27	3069.4	39.77	23.04
D4S1	0.43	15.32	13.34	3.29	3356.3	40.18	36.36
D4S2	0.65	13.31	28.32	3.38	2098.1	40.04	39.10
D4S3	0.87	10.32	29.45	3.43	1217.1	40.38	38.20
D5S1	0.31	12.77	10.89	3.04	2497.7	40.29	61.79
D5S2	0.46	12.12	20.67	3.15	1512.2	40.63	64.64
D5S3	0.54	10.89	24.66	3.16	1014.0	40.47	63.48

Table 7

Mean performance for different traits under interaction of sowing date and genotypes

	MNO	*SYMP*	*B/P*	*Boll Weight*	*Yield Kg/ha*	*GOT*	*CLCuV*
D1V1	0.70	27.33	32.00	3.20	4256.7	39.73	1.39
D1V2	0.86	29.67	40.00	3.37	4630.4	37.89	2.56
D1V3	2.51	23.56	28.56	3.24	4097.7	39.19	5.86
D2V1	0.66	27.00	33.10	3.22	3970.3	40.45	3.34
D2V2	0.83	29.45	42.77	3.42	4140.7	38.44	7.07
D2V3	2.10	25.44	28.45	3.23	3863.4	39.34	18.92
D3V1	0.51	23.01	28.89	3.28	3718.5	41.02	9.90
D3V2	0.56	23.67	33.88	3.40	3485.7	38.51	16.18
D3V3	1.42	18.56	24.78	3.19	2799.2	40.00	85.00
D4V1	0.29	14.22	25.55	3.36	2655.8	41.32	28.00
D4V2	0.41	13.12	26.22	3.50	2493.2	38.64	47.00
D4V3	1.26	11.67	19.32	3.24	2022.6	40.62	84.38
D5V1	0.23	14.22	20.12	3.13	1697.5	41.85	68.90
D5V2	0.31	14.01	18.89	3.18	1476.1	38.68	80.28
D5V3	0.78	7.55	15.34	3.02	1750.3	40.86	96.10

Table 8

Mean performance for different traits under interaction of spacing and genotypes

	MNO	*SYMP*	*B/P*	*Boll Weight*	*Yield Kg/ha*	*GOT*	*CLCuV*
S1V1	0.36	22.60	16.22	3.18	3688.7	41.01	13.36
S1V2	0.41	23.61	17.93	3.34	3713.6	38.52	22.13
S1V3	1.00	18.21	12.21	3.16	3140.3	39.93	42.79
S2V1	0.48	21.66	31.07	3.29	3584.4	40.89	14.97
S2V2	0.59	22.36	37.32	3.41	3648.5	38.38	24.01
S2V3	1.82	17.67	27.07	3.21	3009.6	40.08	45.15
S3V1	0.59	19.27	37.66	3.25	3406.1	40.73	14.83
S3V2	0.77	20.34	41.81	3.37	3513.5	38.40	23.77
S3V3	2.01	16.21	30.62	3.19	2929.9	40.05	44.62

Table 9

Mean performance for different traits under interaction of sowing date, plant spacing and genotypes

Treatment	*MNO*	*SYMP*	*B/P*	*Boll Weight (gm)*	*Yield Kg/ha*	*GOT %*	*CLCuV*
D1S1V1	0.50	29.0	19.0	3.2	4053	40.2	1.57
D1S1V2	0.60	31.0	21.6	3.4	4364	38.2	2.51
D1S1V3	1.40	21.6	15.1	3.3	3930	39.1	5.50
D1S2V1	0.60	27.3	34.6	3.2	4271	40.3	1.33
D1S2V2	0.70	30.7	45.3	3.4	4253	37.7	2.61
D1S2V3	3.20	24.3	31.6	3.2	4040	39.2	6.43
D1S3V1	0.96	25.7	42.3	3.2	4445	38.7	1.27
D1S3V2	1.26	27.3	53.0	3.3	4874	37.9	2.57
D1S3V3	2.90	24.6	39.1	3.2	4653	39.3	5.63
D2S1V1	0.56	26.7	19.0	3.2	3980	40.6	3.33
D2S1V2	0.53	31.3	22.3	3.4	4178	38.5	6.21
D2S1V3	1.36	26.7	15.1	3.2	3789	39.6	15.73
D2S2V1	0.67	28.0	36.7	3.3	4058	40.4	3.20
D2S2V2	0.86	29.1	48.6	3.5	4165	38.5	7.21
D2S2V3	2.40	25.4	32.1	3.3	3847	39.4	19.86
D2S3V1	0.73	26.7	43.3	3.2	3872	40.3	3.51
D2S3V2	1.10	28.0	57.3	3.4	4078	38.4	7.81
D2S3V3	2.53	24.3	38.3	3.2	3953	39.5	21.17
D3S1V1	0.33	25.4	15.6	3.2	3959	41.1	8.03
D3S1V2	0.43	25.7	18.3	3.3	3653	38.7	14.23
D3S1V3	0.90	20.6	13.0	3.2	3241	40.1	39.88
D3S2V1	0.53	23.3	33.0	3.4	3737	40.6	11.23
D3S2V2	0.60	23.4	40.6	3.5	3439	38.4	16.83
D3S2V3	1.50	18.6	27.7	3.2	2770	40.2	40.77
D3S3V1	0.63	20.4	38.1	3.2	3458	41.3	10.41
D3S3V2	0.62	22.0	32.7	3.5	3364	38.4	17.46
D3S3V3	1.86	16.3	33.6	3.1	2386	39.7	41.27
D4S1V1	0.23	17.2	14.3	3.2	3389	41.5	17.53
D4S1V2	0.33	15.4	16.1	3.4	3797	38.7	28.57
D4S1V3	0.73	13.3	9.7	3.2	2882	40.4	63.11
D4S2V1	0.34	14.6	28.7	3.4	3187	41.2	18.07
D4S2V2	0.46	12.7	32.1	3.5	3496	38.6	32.03
D4S2V3	1.17	12.6	24.3	3.2	2611	40.2	67.21
D4S3V1	0.30	10.7	33.6	3.5	2291	41.2	19.41
D4S3V2	0.43	11.3	30.7	3.6	2186	28.6	30.73
D4S3V3	1.87	9.1	24.1	3.3	1974	41.3	64.47
D5S1V1	0.17	15.0	13.1	3.1	2068	41.7	36.37
D5S1V2	0.13	14.6	11.3	3.1	1889	38.6	59.13
D5S1V3	0.63	8.7	8.4	2.9	1558	40.5	89.87
D5S2V1	0.23	14.7	22.4	3.1	1860	41.8	41.03
D5S2V2	0.34	14.3	20.1	3.2	1574	38.6	61.41
D5S2V3	0.80	7.2	19.6	3.1	1479	41.4	91.52
D5S3V1	0.30	13.0	13.7	3.2	1263	42.1	93.57
D5S3V2	0.43	13.1	25.4	3.2	1064	38.7	60.31
D5S3V3	0.90	6.6	18.1	3.1	913	40.6	90.57

Table 10

Incidence of CLCuV % on cotton genotypes planted at different dates

Genotypes	*Days after planting*	*Planting dates*				
		1st May	15th May	30th May	15th June	30th June
MNH-6070	30	0	0	0	10.0	45.0
	45	0	0	0.86	18.0	57.0
	60	0	0.6	2.9	55.0	100.0
	75	0.5	1.7	5.4	55.0	100.0
	90	0.95	2.95	8.1	55.2	100.0
	105	1.39	3.34	9.9	55.2	100.0
MNH-738	30	0	0	1.2	17.0	53.2
	45	0	0.2	10.5	30.0	65.8
	60	0.3	0.95	16.18	70.3	100.0
	75	0.86	2.88	18.2	90.3	100.0
	90	2.3	6.8	35.6	90.3	100.0
	105	2.56	7.7	40.1	90.5	100.0
CIM-496	30	0	0	9.0	30.5	70.0
	45	0.7	1.6	60.0	80.0	90.0
	60	1.85	3.81	70.0	100.0	100.0
	75	3.9	7.3	85.0	100.0	100.0
	90	5.1	14.9	100.0	100.0	100.0
	105	5.86	18.92	100.0	100.0	100.0

Conclusions. From the present study, it is concluded that:

1. CLCuV infestation in early sown cotton reached maximum after 105 days of sowing;
2. CLCuV infestation was maximum within 45 days after sowing in late planting (Later than 15th June);
3. Highest seed cotton yield was recorded in early planting with high plant spacing while maximum seed cotton yield was achieved at low plant spacing (PxP=15cm) in late planting;
4. It is recommended that in late sown cotton (later than 15th June), the plant to plant distance should be 15 cm to compensate the destructive affects of CLCuV on vegetative and reproductive parts of plants.

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