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INTERACTION OF PINK BOLLWORM (LEPIDOPTERA: GELECHIIDAE) POPULATION LEVELS IN PHEROMONE TRAPS AND WEATHER FACTORS

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ABSTRACT

Pink bollworm (*Pectinophora gossypiella*) is a destructive pest of agricultural crops especially cotton crop in Pakistan. It has ability to form rosette flowers, bolls and makes them unable to open. Thus it deteriorates cotton seed quality which has significant impact on yield reduction. Increasing trend of insecticides has resulted in insecticide resistance, environmental pollution and risks of human health. Integrated pest management has key role to reduce negative impacts. Besides of several other components, pheromone traps are best monitoring and mass capturing tool for bollworms in agricultural crops. The study was conducted to check relation of pink bollworm mass trapping in pheromone traps relating to environmental factors during three years study 2018 to 2020. Results indicated that pink bollworm has two peak activity periods during study years. Standard weeks (SW) 11 to 15 and 31-35 were highly active while SW 20 to 26 was inactive periods of pink bollworm. Adult moth population captures in pheromone traps was 3.14, 4.41 and 6.75/ trap during 2018, 2019 and 2020, respectively. Highest peaks were 11.12, 11.85, 15.94 /trap with maximum, minimum, average temperatures, relative humidity and rainfall of 29.43: 36.59: 35.28°C, 11.31: 21.36: 22.80°C, 20.37: 28.96: 29.04°C, 54.66: 61.23:58. 36% and 0.00, 0.00, 0.00 mm, during 2018, 2019 and 2020, respectively. Temperature 20- 30°C had significant impacts to speed activities of pink bollworm. Minimum (r= -0.165, -0.144, -0.582) and maximum (r= -0.078, -0.045, -0.192) temperatures had negative and non- significant correlation with population in pheromone traps while average temperature had positive and significant correlation (r= 0.112, 0.290, 0.486) during study years. Average temperature had maximum impact of 20.9 (0.01), 20.7 (0.03) and 9.3 (0.07) % on population variability during 2018, 2019 and 2020, respectively. Population trends of pink bollworm had shown increasing trends during the subsequent years. Pheromone traps proved best monitoring tool of pink bollworm to integrate into integrated pest management strategy.

Keywords: Bhakkar, lures, pink bollworm, pheromone traps, weather factors

INTRODUCTION

Cotton is the second most widely grown crop (after wheat) in Pakistan, contributing 55% of the exchange rate and 1.0% of gross domestic product (GDP). Cotton yields per hectare are now below average due to severe pest infestation, harmful fertilizer use, limited water availability, increased pathogenic competition and weeds (Vickers, 2017; Asif *et al*., 2021). It is affected by both sucking as well chewing insects that produce high yield loss to cotton crop. The pink bollworm (*Pectinophora gossypiella,* Lepidoptera: Gelechiidae) is one of the most harmful pests of cotton, causing 20-30% ball losses (Khuhro *et al.,* 2015). It damages squares and cotton bolls. Larvae enter into the bolls and feed on the seeds. As the larva bores inside the boll, the lint is cut and tied, resulting in a significant loss of cotton quality. Four generations completes its development on the cotton crop and the fifth generation rests on the leftover bolls on the cotton sticks and the bolls in the ginning factories (Hussain *et al*., 2021). Under dry conditions, the number of larvae in the bolls is directly related to the loss in the yield and quality of the produce. If any control technique does not work in a timely manner, it will lead to a significant yield reduction (Kalola *et al*., 2017). Pheromone traps have been reported be helpful in monitoring and managing these

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moths (Prasannakumar *et al*., 2012). The Pheromone trap is a unique and irrational insect control technique having no adverse effect on the environment and the animals. Female sex pheromone was discovered fist in 1957 and was a combination of two different compounds namely Z, E- and Z, Z- 7,11 hexadecadienyl acetate, also known as gossyplure (Hummel *et al*., 1973). Prior to breeding interference techniques, farmers had to rely on chemical sprayers to treat lepidopterans moths and it led to an imbalance between natural enemies and insect pests (Nandini and Mohan, 2014). Therefore, pheromone traps are designed to attract moths which are an important sample tool to monitor and capture large numbers of flying insects (El-Sayed, 2011). Pheromones traps are usually placed in or around the field. In general, they are used to determine the presence and annual activity of insect species (Shahid *et al*., 2007; Prasannakumar *et al*., 2012). Based on the information gathered from the pheromone traps over time, it can be used to establish predictive models before the onset of events and to adopt integrated pest management strategies more accurately and directly against certain seasonal pest (Ahmad *et al*., 2020). The pink bollworms population is determined by their natural capacity under the influence of various environmental factors. Temperature, day length, humidity and rains are the factors that are responsible for the reproduction and survival. As cold- blooded organisms, the effect of environmental factors greatly influenced (Bale *et al*., 2002). Total number of eggs and the behavior of oviposition depend upon the temperature. Similarly, too much rain can adversely affect insects because the eggs and larvae of these insects can be removed or killed by the rain (Arshad *et al*., 2015). Insects can survive only within certain limits of nature, so one can predict the occurrence of higher insect activity provided by a better understanding of natural preferences. The current study was performed to monitor the population of pink bollworm and its association with abiotic substances such as low, high and normal temperatures, relative humidity (RH) and precipitation (RF).

MATERIALS AND METHODS

Experiment was conducted farmer fields of Bhakkar during three study years 2018 to 2020 under wheat-cotton cropping system throughout the years from January-December to check the population catches in the pheromone traps in relation with environmental factors. 15 traps were installed in one hectare area with each trap 40 m apart and 1.25-1.50m above the ground on the bamboo sticks. Lure EE/ 10, 12-16: Aldwas used in the traps to attract pink bollworm. Lures were changed after every 14 days. Data of total moth catches was recorded on fortnightly intervals. The weather data of maximum, minimum, average temperatures (ºC), relative humidity (%) and rain fall (mm) was collected from observatory at Arid Zone Research Institute, Bhakkar.

Statistical analysis

The data was transformed into square root transformation [SQRT (X+0.5)] before statistical analysis to normalize the data for trap interaction. The data of population captures and weather factors was processed for simple correlation and multiple linear regression to check the variability of population catches by each weather parameter. All the means were separated using least significant (Tukeys HSD) test at *P* 0.05. Coefficient of determination (R_2) and goodness of fit was also determined for the developed models using statistical software Minitab 13 (Minitab, 2013). All the graphical representation were made on Microsoft Excel, 2010 (Katz, 2010).

RESULTS AND DISCUSSION

Pink bollworm is a serious threat to cotton industry of Pakistan. Its intensity is increasing on every cropping season. During three study years 2018-20, its population showed increasing trends. Average population in pheromone traps was 3.14, 4.41 and 6.75/ trap during 2018, 2019 and 2020, respectively. Standard week 3 (January), 7 (February), 43 (November) and 47 (December) were minimum or no activity periods due to low temperature and non-availability of host. While standard week 11 (March), 15 (April), 31 (August) and 35 (September) were high activity periods during these study years. These population trends were correlated with minimum, maximum and average temperatures (ºC), relative humidity (%) and rain fall (mm). Minimum and maximum temperatures had negative and non-significant correlation with population in pheromone traps while average temperature had positive and significant correlation. Rainfall had negative and non-significant correlation during 2018 and 2020 while positive and non-significant correlation during 2019 as shown in (Table 1). During 2018 highest population catches were 11.12, 9.26, 7.69 and 3.48/ trap during standard weeks 11, 15, 31 and 19, respectively. Highest peak population was captured 11.12/ trap with maximum, minimum, average temperature, relative humidity and rainfall of 29.43, 11.31, 20.37ºC, 54.66% and 0.00mm, respectively as shown in Figure 1. There was no significant impact of any meteorological factor on per unit population capture in the pheromone traps due to long term dry season and low average rains during the season. Maximum, minimum, average temperature, relative humidity and rainfall had 1.0, 7.2, 9.3, 1.7 and 0.4% impact, respectively on population change as shown in (Table 2).

Table 1. Correlation between trapped population of pink bollwormand weather factors during 2018 to 2020

Year	TemperatureºC			RH (%)	RF (mm)
	Maximum	Minimum	Average		
2018	-0.078± 0.542	-0.165± 1.120	0.112± 0.818	0.112± 0.315	-0.373± 0.875
2019	-0.045± 0.653	-0.144± 0.630	0.290± 1.210	0.278± 0.491	0.141± 0.743
2020	-0.192± 0.870	-0.582± 1.150	0.301± 0.713	0.486± 0.343	-0.575± 1.648

Table 2. Analysis of Multiple Linear Regression showing relationship of trap population and environmental factors

Year	Regression Equation	R^2	100 R^2	Impact (%)	*P.* Value
2018	$Y=1.278+0.926X_1$	0.010	1.0	1.0	0.64
	$Y=2.0319-0.1229X_1-0.697X_2$	0.082	8.2	7.2	0.11
	$Y=2.419+2.330X_1-0.378X_2-2.107X_3$	0.165	16.5	9.3	0.07
	$Y=2.447+2.259X_1-0.361X_2-2.062X_3+0.106X_4$	0.182	18.2	1.7	0.53
	$Y=2.518+2.302X_1-0.323X_2-2.123X_3+0.134X_4-0.0185X_5$	0.186	18.6	0.4	0.68
2019	$Y=1.8773-0.307X_1$	0.016	1.6	1.6	0.75
	$Y=2.4349-0.1418X_1+0.123X_2$	0.025	2.5	0.9	0.93
	$Y=6.226+2.712X_1-0.363X_2-2.48X_3$*	0.232	23.2	20.7	0.03
	$Y=6.780+0.931X_1+0.569X_2-1.789X_3$* + $1.523X_4$*	0.325	32.5	9.3	0.05
	$Y=14.526+1.055X_1-0.442X_2-1.782X_3+1.054X_4-0.276X_5$	0.428	42.8	10.3	0.04
2020	$Y=0.363-0.853X_1$	0.075	7.5	7.5	0.18
	$Y=2.289+0.196X_1+0.754X_2$*	0.204	20.4	12.9	0.05
	$Y=7.541+5.926X_1++5.123X_2$*$-15.018X_3$ *	0.413	41.3	20.9	0.01
	$Y=6.478+6.555$*$X_1+0.405X_2$*$-5.034X_3$**$-14.01X_4$	0.457	45.7	4.4	0.21
	$Y=7.416+6.676X_1+4.924X_2$*$-14.748X_3$*$+0.157X_4+0.0596X_5$	0.496	49.6	4.5	0.15

Where: X_1 = Maximum Temperature ºC, X_2= Minimum Temperature ºC, X_3 = Average Temperature ºC, X_4 = Relative Humidity (%), X_5 = Rainfall (mm), R^2= Coefficient of determination, *=significant, **=Highly significant, SW= Standard Week

During 2019 highest population catches were 11.85, 9.36, 8.94 and 6.12/ trap during standard weeks 35, 11, 31 and 27, respectively. Highest peak population was captured 11.85/ trap with maximum, minimum, average temperature, relative humidity and rainfall of 36.59, 21.36, 28.96ºC, 61.23% and 0.00mm, respectively as shown in Figure 2.

There was no significant impact 1.6, 0.9% of maximum and minimum temperatures on per unit population capture in the pheromone traps. While average temperature, relative humidity and rainfall had significant impact on per unit population change. Average temperature showed maximum 20.7% followed by rain fall and relative humidity with 10.3 and 9.3% impact, respectively as shown in (Table 2). During 2020 four highest peaks were found. 1st peak population was captured 15.94/ trap with maximum, minimum, average temperature, relative humidity and rainfall of 35.28, 22.80, 29.04ºC, 58.36% and 0.00 mm, respectively on standard week 35. 2nd peak was found13.65/ trap with maximum, minimum, average temperature, relative humidity and rainfall of 29.43, 11.31, 20.37ºC, 60.23% and 0.43 mm, respectively on standard week 11. 3rd peak was found 13.58/trap with maximum, minimum, average temperature, relative humidity and rainfall of 39.78, 27.78, 33.77ºC, 55.23% and 0.00mm, respectively on standard week 31.4th peak was 12.69/ trap with maximum, minimum, average temperature, relative humidity and rainfall of 35.87, 19.00, 27.44ºC, 63.00% and 0.00 mm, respectively on standard week 15 followed by standard week 27 and 19 with population of 7.59 and 6.36/ trap as shown in figure 3. There was no significant impact 7.5, 4.5, 4.4% of maximum temperature, relative humidity and rain fall on per unit population capture in the pheromone traps, respectively. While average temperature had had significant impact on per unit population change of 20.9% followed by minimum temperature having impact 12.9% as shown in table 2. Ahmad *et al*. (2020) supported our studies as he reported that high and low temperatures had a negative but non-significant association with moth captures of pink bollworm, spotted bollworm and American bollworm. A negative association existed between the American and armyworm-related relative humidity but a good relationship with the pink bollworm and the spotted bollworm, respectively. He also pointed out that the number of moths/ traps of pink bollworm were maximum during all observed months. Pink bollworm moths in each trap gradually increase in March when temperatures rise from 25˚C. A high number of moth catches were present recorded when the maximum temperature was 35˚C and the minimum was 25˚C in April. In our studies the peaks were on standard week (SW) 11-15 and 31-35. These studies almost supported by Kalola *et al*. (2017) where he found incidence of pink bollworm was at its peak during 5th SW and remained active up to 15th SW. After this pest population decreased abruptly and no insect activity was observed between 31-36 SW. He reported 87% variations in population of pink bollworm. While our studies found maximum up to 21% variations. This difference is due to different geographical conditions. Asif *et al*. (2021) also showed high variations as he reported that regression analysis have shown that the weather conditions found 76.4, 91.4 and 69.4% variations in the pink bollworm populations. Pink bollworm was active all the years with the lowest moth catch recorded in June. Significant population reductions were recorded in the hot summer months such as May to July and after that their numbers reached at its peak in September. The trapping was positive correlated with the temperature and relative humidity throughout the three years during 2016, 2017 and 2018, respectively. Dhawan and Simwat (1996) reported highest peaks in 36-39 SW and 28-30 SW which is in accordance with our findings. Arshad *et al.* (2015) reported the incidence of pink bollworm was high at the end of August which is SW 31 as in our findings. Ali *et al*. (2016) did not supported our results as he reported a positive correlation of high temperature and rain with moth catches of pink bollworm with 72.75% impact of weather factors. According to our findings Shinde and Patil (2018) also found a negative association of high, low temperatures and humidity with moth trapping in pheromone traps. But he found different peaks and population intensity during his studies. He reported pink bollworm population capturing was 36.2 moth/ trap in 42nd SW of October, after which there was a gradual increase in adult catching on the 44th SW (98.5 moths /trap) of November 2016-17. During the 2017-18 seasons, trapping started to reach its peak 158.35 moths/ trap on 43rd SW of October and the second highest catch of adults was seen on the 48th SW (119.21 moth/trap) of November. However population levels in our studies were supported by Nissar and Akshitha (2016) who reported the pink bollworm moth population varied from 3-14 moths/ trap.

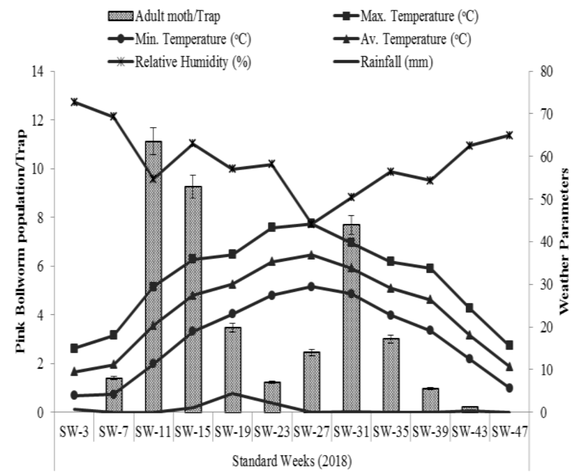

Figure 1. Moth catches of pink bollworm versus weather factors during 2018

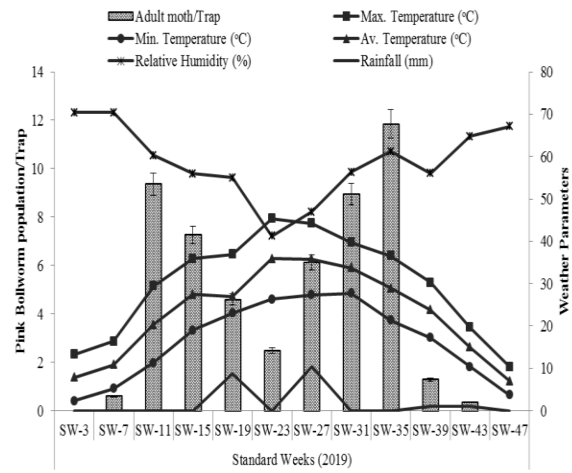

Figure 2. Moth catches of pink bollworm versus weather factors during 2019

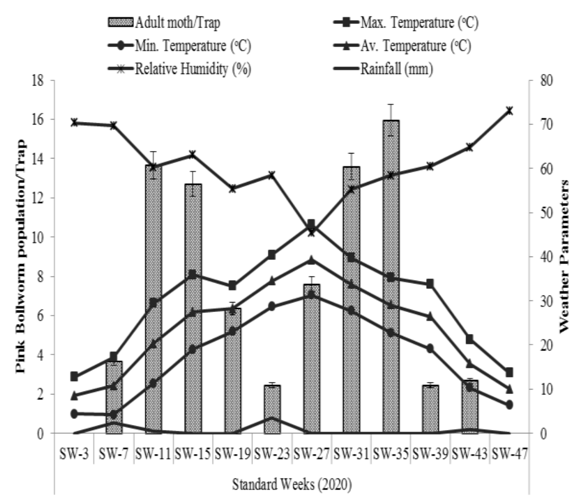

Figure 3. Moth catches of pink bollworm versus weather factors during 2020

The incidence of pink bollworm was 8.2/ traps which began in September and gradually rise until November on 45th SW (Byers and Naranjo, 2014; Sarma *et al.,* 2015; Shinde and Patil, 2018). Several other scientists also studied and supported the importance of pheromone traps as in our studies (Pontes de Melo *et al*., 2012; Babu and Meghwal, 2014; Khuhro *et al*., 2015; Sarma *et al*., 2015).

CONCLUSION

It is concluded that pheromone traps as forecasting tool are very useful to monitor the pink bollworm throughout the year under the optimum temperatures for this pest. These models warn us against pest attack in the future from the pest losses. This will helpful to device a control strategy before the onset of the pest attack.

AUTHOR’S CONTRIBUTION

M. Abbas: Conducted research, wrote manuscript
S. Abbas: Data collected and statistical analysed
M. Ramzan: Planned research
N. Hussain: Reviewed literature
M.Khaliq: Proof reading

REFERENCES

Ahmad, A. Raza, M. Akram, M. Aslam, W. Nazir, A. L. K. Tipu, Shahid, M. Karim, A. Rafiq and M. Shakeel. 2020. Influence of abiotic factors on mass capturing of lepidopterous moths by sex pheromone traps. Journal of Pure Applied Biology, 9 (4): 2609-2616.

Ali, A., F. Hafeez, M. Farooq, H. Karar, M. Abbas and T. K. Babar. 2016. Influence of weather factors on the trapped population of pink bollworm (*Pectinophora gossypiella*) under Multan Agro-ecosystem. Journal of Entomology Zoology Studies, 4 (5): 02-06.

Arshad, M., M. Gogi, M. Arif and R. Khan. 2015. Seasonal Pattern of Infestation by Spotted Bollworm *Earias insulana* (Boisd.) and Pink Bollworm *Pectinophora gossypiella* (Saund.) in field plots of Transgenic Bt and non-Bt Cottons. Pakistan Journal of Zoology, 47 (1): 177-186.

Asif, M. U., R. Muhammad, W. Akbar, M. Sohail, M. Awais and J. A. Tariq. 2021. Seasonal abundance of adult Pink Bollworm, *Pectinophora gossypiella* (Saunders) at Tandojam, Pakistan. Pakistan Journal of Zoology, 53 (1): 1-4.

Babu, S. R. and M. L. Meghwal. 2014. Population dynamics and monitoring of sucking pests and bollworms on Bt cotton in humid zone of southern Rajasthan.The Bioscan, 9 (2): 629-632.

Bale, J. S., G. J. Masters, I. D. Hodkinson, C. Awmack, T. M. Bezemer, V. K. Brown, J. Butterfield, A. Buse, J. C. Coulson and J. Farrar. 2002. Herbivory in global climate change research: direct effects of rising temperature on insect herbivores. Global Change Biology, 8 (1):1-16.

Byers, J. A. and S. E. Naranjo. 2014. Detection and monitoring of pink bollworm moths and invasive insects using pheromone traps and encounter rate models. Journal of applied ecology, 51 (4): 1041-1049.

Dhawan, A. and G. Simwat. 1996. Monitoring the seasonal abundance of cotton bollworms with pheromone traps. Indian Journal of Ecology, 23 (2): 123-129.

El-Sayed, A. M. 2011. The pherobase: database of insect pheromones and semiochemicals. See http://www. pherobase. com.

Hummel, H., L. Gaston, H. Shorey, K. Byrni and R. Silverstein. 1973. Clarification of the chemical status of the pink bollworm sex pheromone. Science, 181 (4102): 873-875.

Hussain, S., M. Asi, H. Anwar, F. Ahmad, A. Rehman, M. N. Shahid, U. D. Umar, M.A. Zulfiqar and M. Ijaz. 2021. Efficacy of PB Ropes (Synthetic Sex Pheromone) against Pink Bollworm, *Pectinophora gossypiella*, destructive cotton pest, in different ecological zones of Punjab, Pakistan. Pakistan Journal of Agricultural Research, 34 (3): 462-472.

Kalola, A., D. Parmar, G. Motka, P. Vaishnav, T. Bharpoda and P. Borad. 2017. Weather based relationship of adult moth catches of pink bollworm (*P. gossypiella*) and leaf eating caterpillar (*S. litura*) in cotton growing area of Anand, Gujarat. Journal of Agrometeorology, 19 (1): 75-77.

Katz, A. 2010. Microsoft Excel 2010. Style, 21-39.

Khuhro, F. Ahmad, A. Kalroo, K. Abdullah and M. Talpur. 2015. Monitoring and Population Dynamics of Pink Bollworm on Cotton in Different Cotton Growing Areas of Sindh-Pakistan. International Journal of Inter-disciplinary Research in Science Society Culture, 1 (2): 51-60.

Minitab, L. 2013. Minitab. State College, Centre County, Pennsylvania, United States. PA

16801. Data Universal Number System (DUNS) No.107326043.

Nandini, S. and S. Mohan. 2014. Monitoring of Cotton pink bollworm, *Pectinophora gossypiella* through pheromone trap and impact of Abiotic factors. Annals of Plant Protection Sciences, 22 (1): 1-4.

Nissar, V. and H. Akshitha. 2016. ICAR-All India Coordinated Research Project on Spices. ICAR-All India Coordinated Research Project on Spices: Annual Report, 2015-16

Pontes de Melo, E., P. Degrande, R. Aveiro Cessa, I. Dos Santos de Lima Junior, R. Barros and R. Fernandes Nogueira. 2012. Behavior of *Pectinophora gossypiella* (Pink Bollworm) Males monitored with pheromone trap in cotton. Acta Biologica Colombiana, 17 (3): 625-634.

Prasannakumar, N., A. Chakravarthy and A. Naveen. 2012. Influence of weather parameters on pheromone trap catches of potato cutworm, *Spodoptera litura* F. (Lepidoptera: Noctuidae). Current Biotica, 5 (4): 508-512.

Sarma, M., Agarwal, Y. Reddy, K. Kumar and Y. Padmalatha. 2015. Seasonal dynamics of insect pests of cotton in scarce rainfall zone of Andhra Pradesh. Journal of Insect Science, 28 (1): 53-57.

Shahid, M. R., A. Suhail, M. J. Arif, M. D. Gogi, M. A. Shahzad and S. Hussain. 2007. Effectiveness of *Trichogramma chilonis* against sugarcane stem borer (*Chilo infuscatellus* Snellen). Pakistan Entomologist, 29 (2): 141-146.

Shinde, P. R. and U. H. P. Patil. 2018. Seasonal population fluctuation of pink bollworm, *Pectinophora gossypiella* (Saund.) as monitored by gossyplure. Journal of Entomology and Zoology Studies, 6 (5): 1998-2000.

Vickers, N. J. 2017. Animal communication: When i'm calling you, will you answer too. Current Biology, 27 (14): 713-7115.

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