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Research Article

Responses of different aphid species on wheat crop with relation to abiotic factors

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Abstract

Wheat (*Triticum aestivum* L.) is one of the major stable food and cereal crop in all over the world as well as in Pakistan. However, it attached by various insect pests. The aphids, particularly *Rhopalosiphum padi* (L*)*, *Schizaphis graminum* (L) and *Sitobion avenae* (F) species are among the major causes that severely affect wheat production across world. The main objective of this study was to check population dynamic of different aphid species with relation to abiotic factors. The experiment was conducted at Arid Zone Research Institute Bhakkar on three wheat varieties i.e. Fakhar-E-Bhakkar, Bhakkar Star, and Nishan 2021 under Randomized Completely Block Design. The mean population of three aphid species per tiller recorded every week by counting the number of aphids on ten tillers selected randomly from each selected field. The result of current study showed that the infestation of three aphids' species was started in the 2nd week of February. The population of aphids per tiller increased as the vegetative growth proceeded and was highest in the 3rd week of March. The *R. padi* was most dominant from 2nd week of February to 1st week of March. *S. graminum* was most dominant from 1st week to 3rd week of March, and similarly *S.avenae* was most dominant 2nd to 3rd week of March. Correlation of population dynamic of aphids with temperature and humidity had positive and significant impact on stem population i.e. (0.6150± 0.05) and (0.873±0.023), respectively. Temperature had positive and significant impact (0.264±0.614), but humidity had positive and non-significant impact (0.245±0.640) on leaves. While positive and non-significant impact on spike i.e. (0.372±0.467) and (0.084±0.875), respectively.

Keywords: Abiotic factors; Aphid; Bhakkar; Frequency; Wheat

Introduction

Wheat is most significant cereal crop in agriculture and it is farmed on more acreage than any other crop and ranks third in terms of global population after rice and corn. According to Pakistan's official study, it is grown by around 80% of farmers on about 9 million hectares, or near to 40% of the country's total cultivated land. Crop meet 37% of total dietary energy and protein consumption. Pakistan's total wheat production in 2021 was 27 million tones.

This production still low as compared to the developed countries. There are various factors responsible for low production of wheat in Pakistan such as drought, fluctuating temperature, rains and pests [1-3]. Wheat aphids one of the major factors contributing to the low production of wheat in Pakistan. Wheat aphids cause significant yield losses [4]. Different patterns of dynamic pests as a result of climate variation are a big challenge to ensure the stability and sustainability of wheat and its products [5]. Warm temperature conditions have been reported to alter soil bacteria and insect pests [6]. Wheat insect pests come in a variety of forms, from sowing to harvest, the Isoptera (wheat termites) infest wheat crops. Termites are responsible for 43-80 percent yield losses at growing and final stage in wheat crop [7]. Caterpillar is also responsible for damage of wheat crop and feed upon leaves [8]. There is various type of caterpillars caused damage to wheat crop. The *Helicoverpa armigera* which is most destructive pest of wheat crop and more than 2 billion dollars economic losses have been reported each year [9]. Army worm is distributed worldwide and destructive pest of many crop i.e. *Oryza sativa, Triticum aestivum and Zea mays* [10]. Aphids are the most destructive pests of all cultivated crops worldwide. At this time, 92 aphid species have been recorded in Pakistan [11]. There are three major species that damage the wheat crop. *Rhopalosiphum padi* and *Schizaphis graminum* cause significant damage to wheat crops all over the world, and *Sitibion avnae* also causes severe damage to wheat crops. Aphids also spread a variety of viral infections in wheat crops by sucking phloem sap and disrupting their development. Aphids are mostly pale green in colour, with a few black or red species, and have wing or wingless structures. Aphid population attack on wheat kernels, stems, and tillers, as well as connected leaves, is severe; it occurs in groups or individually. The density of aphid species fluctuates according to the stage of wheat growth [12]. These wheat aphids commonly feed on wheat crops and cause damage by feeding directly on shoots and leaves, producing leaf deformation, curling, and chlorosis [13]. The increased production of honeydew also harms the plants indirectly [14]. *Rhopalosiphum padi, Schizaphis graminum* (L) and *Sitobion avenae* (F) are three important insect pests of wheat crops in Pakistan [15] and around the world [16]. These are polyphagous sucking insects with a global distribution [17] that cause a 15% loss in wheat crop production during the flowering stage [7]. If the temperature remains cool until the end of March, hot crops grown late in the season may face a significant risk of aphid infestation [18]. The aphid outbreak could be managed if cereal crops were planted earlier in the season [19]. Low aphid infestation on early-planted wheat fields. Early maturing wheat cultivars can escape aphid infestation [20], but late sowing enhances infestation, leading to yield reduction. Wheat aphid population dynamics are influenced by environmental conditions. The damage caused by various aphid species to wheat yield is approximately 80%, and the damage is done by transferring viral and fungal diseases and secreting honey dews. Temperature is the most important abiotic factor affecting the reproduction rate, physiology of aphids [21] and ultimately the population dynamics of wheat aphids [22]. During high temperatures, the metabolism of insects increased, so they produced more generations and dispersed, although their life cycle became short [23]. In 2010, it was reported that aphids have a positive relationship with maximum and minimum temperatures and a negative association with relative humidity. Rainfall has a positive but non-significant relationship with aphid population dynamics [24]. The objectives of the current studies were to determined

population density of different wheat aphid species in relation to the abiotic factors.

Materials and Methods

The current study was conducted at Arid Zone Research Institute Bhakkar (AZRI) farm during the year 2022 on population fluctuations of wheat aphid with relation to abiotic factors under RCBD (Randomized complete block design). Three wheat aphid species *Sitobion avenae*, *Schizaphis graminum* and *Rhopalosiphum padi* were found infestating wheat crop at different growth stages of three varieties i.e. Fakhar-E-Bhakkar, Bhakkar Star and Nishan 2021. Data was recorded on weekly basis by counting aphid population on per tiller basis. Three plots of each variety were selected at different locations having plot size 100x50 m. At each plot, ten spots were randomly spaced along a diagonal across the field and from each spot one tiller was selected aphid population was recorded separately from stem, leaf and spike. Aphid population was counted by paper shake method. Each tiller was gently shaken on white paper and aphids were counted by naked eye. Every aphid species was identified on the basis their following morphological characters and counts were recorded separately.

Rphalosiphum padi

Dark green, olive toned, globular, with broad rust coloured patch at the base of cornicles, antennae short (about half length of body) cauda short, cornicles cylindrical and two time longer than the cauda.

Schizaphis graminum

Elongate, pale green to yellowish, with a dark green longitudinal line on dorsum, cornicles straight, medium in length and darkened little a tip, antennae short, cauda elongate and pale in colour, wing with medial vein one branched.

Sitobion avenae

Yellow, green, or red with dark lateral spots, antennae long black, cornicles medium length, black, straight and reticulated, cauda long and light coloured.

Data was subjected under statistical analysis (a-0.05). Analysis of variance was computed using window based computer program statistic 8.1 at 5% level of significance. Tukey HSD test was applied to determine pair wise comparison of mean.

Results and Discussion

The population dynamics of these three aphid species remained different from each other. Wheat aphid infestation started in the second week of February (*F value*. 6.76, *P value*. 0.0521, RE. 0.84), gradually increased, and reached a peak in the 3rd week of March (*F value*. 6.72, *P value*. 0.0526, RE. 0.87). Results revealed that the *R. padi* population peaked (5.1 aphids per tiller) in the 2ndweek of February (*F value*. 6.76, *P value*. 0.0521, RE. 0.84) and gradually decreased (0.7) in the 3rdweek of March (*F value*. 6.72, *P value*. 0.0526, RE. 0.87) on stem as shown in (Fig. 1 & Table 1). On leaves population was significantly maximum in February and gradually decreased in March as shown in (Fig. 2). On spike population showed different trend as the aphid population was minimum in the second week of February (*F value*. 6.59, *P value*. 0.0542, RE. 1.39), (2.03 aphid per tiller) and increased in the third weeks of February (*F value*. 6.47, *P value*. 0.0558, RE. 0.86), (4 aphid per tiller) and in last week of February to 3rdweek of March (*F value*. 6.22, *P value*. 0.0592, RE. 0.86) as shown in (Fig. 3). *S. graminum* stem population dynamics was minimum in the 2nd week of February(*F value*. 6.76, *P value*. 0.0521, RE. 0.84), (1.83 aphids per tiller) and gradually increased to reach a peak (5.8 aphids per tiller) in the 3rd week of March (*F value*. 6.72, *P value*. 0.0526, RE. 0.87) as shown in (Fig. 1). On leaves aphid population was significantly minimum (1.41 aphids per tiller) in 2ndweek of February (*F value*. 6.44, *P value*. 0.0562, RE. 1.14), and gradually increased to maximum number of population (5 aphids per tiller) in 3rd week of March (*F

value. 6.22, *P value*. 0.0592, RE. 0.86) as show in (Fig. 2 & Table 2). On spike minimum number (1.1 aphids per tiller) of aphid population recorded in 2nd week of February (*F value*. 6.59, *P value*. 0.0542, RE. 1.39), that increased gradually and reached on peak (5.2 aphids per tiller) in 3rd week of March (*F value*. 6.22, *P value*. 0.0592, RE. 0.86) as show in (Fig. 3 & Table 3). Results showed that *Sitobion avenae* population was minimum (1.1 aphid per tiller) in the 2nd week of February (*F value*. 6.76, *P value*. 0.0521, RE. 0.84), and gradually increased and reached on peak in 3rd week of March (*F value*. 6.72, *P value*. 0.0526, RE. 0.87) on stem as show in (Fig. 1). Similar result was obtained on both leaves and spike as show in (Fig. 2 & 3).

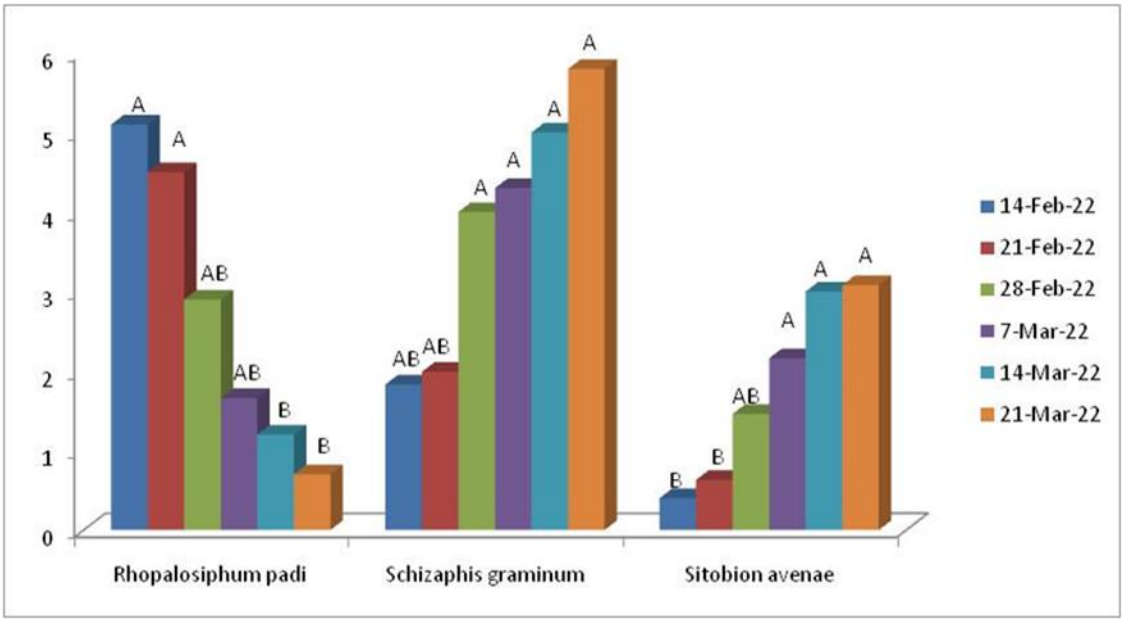

Figure 1. Mean number of aphid population on stem during various standard weeks

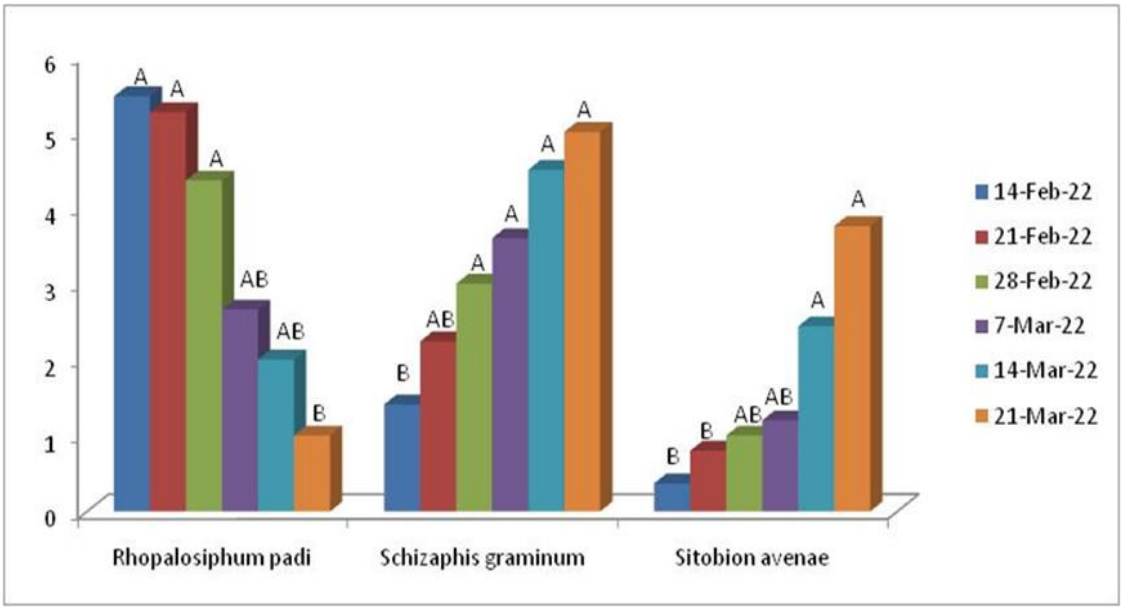

Figure 2. Mean number of aphid population on leaves during various standard weeks

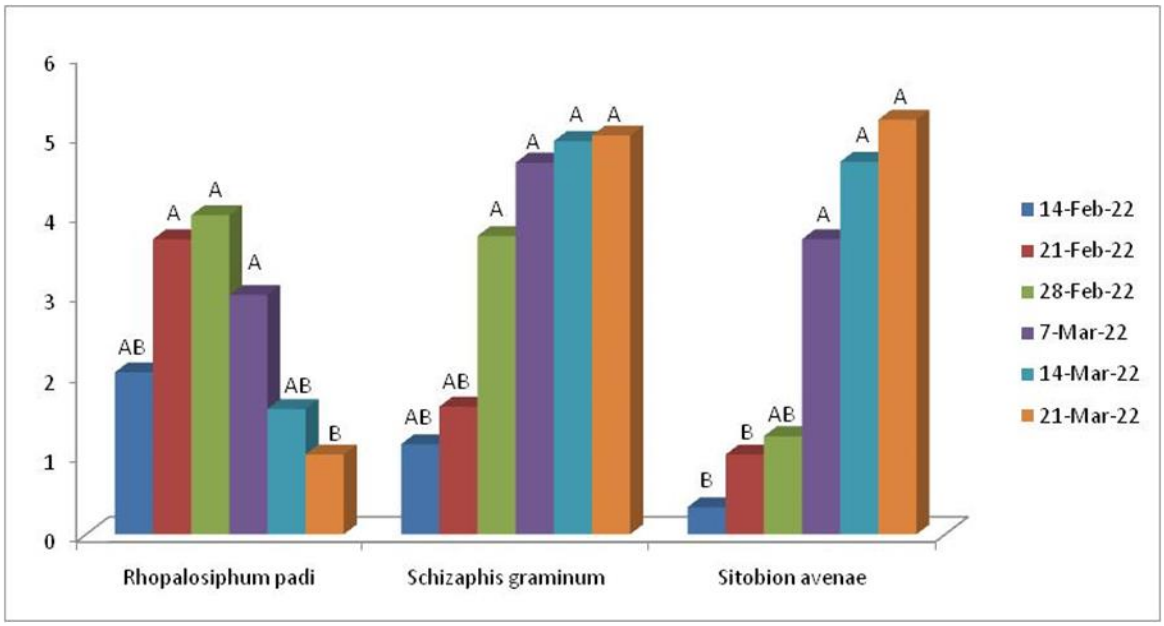

Figure 3. Mean number of aphid population on spike during various standard weeks

Table 1. Analysis of variance for aphid population on wheat tillers during study period

S. No.	Month	F value	P value	CV (%)	RE (Relative Efficiency)
1	February (2nd week)	6.76	0.0521	65.64	0.84
2	February (3rd week)	6.64	0.0536	57.55	0.73
3	February (4th week)	6.42	0.0565	31.14	1.02
4	March (1st week)	6.67	0.0532	40.7	1.03
5	March (2nd week)	6.48	0.0556	45.98	0.75
6	March (3rd week)	6.72	0.0526	25.46	0.87

Table 2. Analysis of variance for aphid population on wheat Leaves during study period

S. No.	Month	F value	P value	CV (%)	RE (Relative Efficiency)
1	February (2nd week)	6.44	0.0562	60.45	1.14
2	February (3rd week)	6.85	0.0511	66.34	0.84
3	February (4th week)	6.68	0.0531	49.7	0.73
4	March (1st week)	6.28	0.0584	33.67	1
5	March (2nd week)	6.25	0.0587	57	1.37
6	March (3rd week)	6.22	0.0592	31.64	0.86

Table 3. Analysis of variance for aphid population on wheat spike during study period

S. No.	Month	F value	P value	CV (%)	RE (Relative Efficiency)
1	February (2nd week)	6.59	0.0542	48.76	1.39
2	February (3rd week)	6.47	0.0558	59.7	0.86
3	February (4th week)	6.87	0.0508	32.54	1.11
4	March (1st week)	6.23	0.0516	47.12	0.76
5	March (2nd week)	6.53	0.0549	34.03	0.81
6	March (3rd week)	6.22	0.0592	31.64	0.86

Corelation of population dynamic of wheat aphid (Table 4) showed that temperature and humidity had positive and significant impact on population fluctuation on stem (0.6150± 0.05) and (0.873±0.023), according to (Table 4) temperature had positive and significant impact on population fluctuation (0.264±0.614) while humidity had positive and non significant impact on population fluctuation on leaves (0.245±0.640). Table 4 also showed that temperature and humidity had positive and non significant impact on population fluctuation on spike (0.372±0.467) and (0.084±0.875). The regression equation (Table 5) revealed that temperature had 37.8 % impact on per unit population change. While humidity had 50.4 % impact on population change on wheat stems. The (Table 5) showed that temperature had 60.5 % impact on per unit population change. While humidity had 31.3 % impact on population change on wheat leaves. Temperature had 49.3 % impact on per unit population change. While humidity had 34.7 % impact on population change on wheat spike as show in (Table 5). Aphids are serious sucking pest of wheat crop **[25]**. Population of aphid was at minimum level during the February and maximum in March, after this it decreased abruptly and disappeared after the 1st week of April **[26]**. Our study has found the increase in population trend from tillering stage towards the heading stage. Similar results were found by Hussein **[27]** where abundance of each aphid specie was found at the start of the flowering period after this population fell rapidly. According to him a maximum abundance of each aphid species occurred at the beginning of flowering period, after which the population fell rapidly. Many other scientists worked on the population dynamic of wheat aphid. Such as **[24, 28-31]** found highest peaks of aphid population during March. Singh *et al*. **[32]** found highest peaks during 2nd week of January. Xiong **[33]** found highest peaks during 4th week of February. Nawaz **[34]** found highest peaks at milking stage during 3rd week of March. Rustamani *et al*. **[26]** found highest peaks at heading or earing stage. Wheat has three major infesting aphid species i.e. *Rhopalosiphum padi*, *Schizaphis graminum* and *Sitobion avenae* with varying periods of infestation. *R. padi* was the 1st specie which appeared the wheat crop and fed mostly on the leaves and shoots. *S. graminum* was appeared after the *R. padi* and fed mostly on the shoots and ears. S. avenae appeared after the both of above species and remained mostly on flowers/ears. This study was confirmed by Jarosik *et al*. **[35]** who reported that *R. padi* and *S. avenae* are most destructive species on winter wheat where *R. padi* mostly feed on leaves and ears while *S. avenae* feeds on ears of wheat. *R. padi* was dominant from mid-February to mid-March, S. *graminum* and S.avenae during month of March (1st to 3rd week). This study was confirmed by Shahzad *et al*. **[36]** who observed two species i.e. *R. padi* and *S. graminum* on wheat crop where *S. graminum* was dominant over *R. padi* on the last week of March. Incidence of these species was observed in order *R. padi*>*S. graminum*>*S. avenae*. period Aheer *et al.* **[30]** found that aphid population decreased when maximum and minimum temperatures reached their optimum limits of 27.30°C and 24°C, respectively. Our findings are also support the above statement, as aphid populations are minimum at the beginning of February (temperature <16C^0) and the end of March (temperature > 27C^0). It was also discovered that the aphid attack peaked in the third week of March, when the temperature was in the aphid-friendly zone. A number of factors influence the rate at which aphid populations grow and decline **[30]**. The findings of Aslam *et al.* **[37]** that temperature fluctuations began to increase their population were in line with the above said. Our finding showed that higher relative

humidity had a positive impact on wheat aphid population growth, hence our findings did not match with Srivastava and Akhtar [38] who state that declined Rh% improves helpful in the process of population growth [38]. The aphid attack started in mid-January on the wheat cultivars and increased gradually with the growth of the plants [4]. Published information reveals that aphids are serious pests of wheat crops [25]. They have also been implicated in the transmission of the BYDV disease of wheat. The increase in population was gradual from the vegetative growth stage to inflorescence. Similar results were also observed by Hussein [27]. According to him, the maximum abundance of each aphid species occurred at the beginning of the flowering period, after which the population fell rapidly. Rustamani *et al.* [26] observed that the infestation of aphids appeared during the 3rd week of December on all wheat varieties. The increase in population was gradual during the vegetative growth stage, but the aphids multiplied rapidly during the reproductive stage. The variation in the aphid density tiller-1 in different varieties could be the resistance response of these varieties to aphid attack. These have become serious pests of wheat (*Triticum aestivum* L.) in Pakistan and yield losses are positively correlated with aphid populations [4]. In addition to this, aphids as pathogen vectors play a significant role in transmitting many fungal and viral diseases in plants [39]. Aphid population has been steadily increasing since the 5th observation date (16th March), reaching a peak in mid-March and the final highest mean population was recorded on the 21st of March. First week of April (3rd April), the lowest mean aphid population was recorded on all wheat varieties. Climate factors considerably influence the aphid pest populations [22]. Temperature is considered the most important a-biotic factor affecting physiology [21], aphid reproduction rates [21] and, consequently, aphid population dynamics [40].

Table 4. Corelation of the population dynamic of wheat aphid with Temperature and Relative humidity

Vegetative Parts	Temperature ºC	Relative Humidity
Stem	0.6150±0.05	0.873±0.023
Leaves	0.264±0.614	0.245±0.640
Spike	0.372±0.467	0.084±0.875

Table 5. Analysis of Multiple Liner Regression showing relationship between population dynamic of wheat aphid with Temperature and Relative humidity

Vegetative Parts	Regression Equation	100 R (%)	Impact (%)	P.Value
Stem	Y= -7.1+ 0.601 X1	37.8	37.8	0.519
	Y= 95.4-0.735 X1-1.70 X2	88.2	50.4	0.047
Leaves	Y= 2.08+0.191 X1	60.5	60.5	0.832
	Y= 4.6+0.158X1-0.042X2	29.2	31.3	0.944
Spike	Y= -11.6+0.699 X1	49.3	49.3	0.637
	Y= -261+3.94X1+4.12X2	14.6	34.7	0.006

Conclusion

It is concluded that last fortnight of March was maximum activity period of aphid activity. However density of different aphid species varied with time depending upon the abiotic factors especially temperature

reached from 25^0C-30 ^{0}C. *S. avenae* proved most destructive because it feed directly on wheat spike.

Authors' contributions

Conceived and designed the experiments: M Abbas & M Saleem, Performed the experiments: RM Asghar & K Hussain, Analyzed the data: D Hussain, M Hussain, M Irshad, M Khaliq & Z Perveen, Contributed materials/ analysis/ tools: M Nadeem & A Ghaffar, Wrote the paper: M Abbas & M Saleem.

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