PHENOLOGY AND GRAIN YIELD OF GUAR IN RELATION TO POTASSIUM AND PHOSPHORUS

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ABSTRACT

The soils of Pakistan are deficient in phosphorus and potassium thus there is a dire need to detect and recommend the optimum dose of these important nutrients for every crop. The present experiment was designed to study the response of crop stand establishment and grain yield of guar (*Cyamopsis tetragonoloba* L.) to potassium and phosphorous in a field trial at the University of Agriculture Peshawar, Pakistan during 2016. Three levels of phosphorus (40, 80, 120 kg ha^{-1}) and three levels of potash (20, 40, 60 kg ha^{-1}) along with control were applied to guar in randomized complete block design (RCBD) with three replications. Phosphorus and potassium were supplied from diammonium Phosphate and muriate of potash. Phosphorous had significantly affected emergence m^{-2}, days to pods formation, and grain yield. Maximum emergence m^{-2} (54) and minimum days to pods formation (60) were recorded at 40 kg phosphorus ha^{-1}. Maximum grain yield (1120 kg ha^{-1}) was recorded at 120 kg phosphorus ha^{-1}. Potassium significantly affected emergence m^{-2}, thousand-grain weight, and grain yield. Maximum emergence m^{-2} (54) was recorded at 20 kg potassium ha^{-1}, maximum thousand-grain weight (42 g) was recorded at 40 kg potassium ha^{-1} and maximum grain yield (1082 kg ha^{-1}) was observed at 60 kg potassium ha^{-1}. P and K significantly increased grain yield and thousand-grain weight compared with control. It is concluded that 40 kg phosphorous ha^{-1} and potassium 20 kg ha^{-1} resulted in optimum yield of guar and recommended for general cultivation in agro-climatic conditions of Peshawar.

Key words: Guar, grain yield, potassium and phosphorus

INTRODUCTION

Guar (*Cymopsis tetraglonoloba)* belongs to the family leguminacea and is a determinate, water stress-tolerant summer legume crop known for fodder purpose in Pakistan (Adasms *et* *al*., 2020). In Pakistan, guar is grown on an area of 0.24 million hectare with annual production of 1.46 million tons and average yield of 630 kg ha^{-1} which is less than India and other countries. Pakistan is the major exporter of guar gum that fulfills 10%-15% of world demand (Manjunatha *et al*., 2018). There are many factors responsible for minimum production of guar among which crop nutrition is the major factor. Among nutrients phosphorus is the main limiting factor because guar being leguminous crop requires more phosphorus (Itilema *et al*., 2018).

As the soil of Pakistan is extremely deficit in available phosphorus (Irfan *et al*., 2019) so, supply of phosphorus is necessary for maintaining crop growth and improving the nutritional profile of dry matter and potential benefits of biological nitrogen fixation. Phosphorus application increases the plant biomass (Zhang *et al*., 2020) and improves the protein contents as well (Duncan *et al*., 2018). Minimum phosphorus level in soil affects the functionality of nitrogen fixing bacteria in leguminous crops (Míguez-Montero *et al*., 2020)

Potassium (K) is the 3rd most important nutrient after nitrogen and phosphorus (Sun *et al*., 2018). The importance of K in fertilization process was felt to be necessary after the results of doctrine study of Von Liebig in 1840. Its sufficient supply during crop growth periods improves water relation of plant and photosynthesis (Chan *et al*., 2021). Phosphorus and potassium application is mandatory for the production of quality forage and to improve the dry matter and green fodder production in cluster beans (Sher *et al*., 2022). Application of potassium is also significant as phosphorus alone cannot improve the dry matter production and forage quality of fodder crops (Baghdadi *et al*., 2018). Among the forage quality, crude protein content is more responsive to phosphorus and potassium than to all other nutrients. Plants require abundance of potassium as it is the basic and macro nutrient (Jan and Hussain. 2022). Phosphorous is important for energy transformation in plant cell, early root development, flowering and seed development (Ahmad *et al*., 2022).

MATERIALS AND METHODS

An experiment on the "the effect of different levels of potassium and phosphorus on yield and yield components of guar" was conducted at Agronomy Research Farm, University of Agriculture Peshawar during kharief season 2016. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The following treatments were used in experiments.

Factor A: Phosphorus (kg ha^{-1}) **Factor B:** Potassium (kg ha^{-1})

P_1=40	K_1=20
P_2=80	K_2=40
P_3=120	K_3=60

Phosphorous and potassium were applied in the following combination,

T1= P_1 K_1	=	40:20
T2=P_1 K_2	=	40:40
T3=P_1 K_3	=	40:60
T4=P_2 K_1	=	80:20
T5=P_2 K_2	=	80:40
T6=P_2 K_3	=	80:60
T7=P_3 K_1	=	120:20
T8=P_3 K_2	=	120:40
T9=P_3 K_3	=	120:60
T10	=	control (no P and K)

The experiment was laid out on plot size of 5.40 m^2 having 4 rows, 45 cm apart and 4m long. Seed was used @ 50 kg ha^{-1}.The starting dose of N 40 kg ha^{-1} was applied at the time of sowing. Weeds were controlled by 1-2 hoeing at the initial growth stages and also with the application of post emergence herbicides (Treflan 4 EC). The data were subjected to ANOVA and the treatments mean were compared by LSD at 5% level of probability (Steel and Terrie, 1984).

RESULTS AND DISCUSSION

Emergence $m^{-2:}$.Statistical analysis of the data showed that potassium (K), phosphorous (P) and control vs. rest significantly affected the emergence m^{-2}, while K x P interaction showed non-significant effect on emergence m^{-2} (Table 01). Minimum emergence m^{-2} (40.3) was observed in control plots. Higher level of K (60 kg ha^{-1}) gave lesser emergence m^{-2} (52). Emergence m^{-2} increased with decrease in K level and maximum emergence m^{-2} (54) was noted at 20 kg K ha^{-1}. Higher level of P (80 kg ha^{-1}) caused lesser emergence m^{-2} (51). Emergence m^{-2} increased with decrease in P level up to 40 kg P ha^{-1}(54). Thereafter, further decrease in P did not enhance emergence m^{-2}. Interaction of P x K revealed that fewer emergence m^{-2} (49) was recorded from 80 kg P x 60 kg K ha^{-1}, while maximum emergence m^{-2} (55.3) was recorded from 40 kg P x 20 kg K ha^{-1} (Figure 1). It is concluded from present result that emergence m^{-2} were increased with decrease in K levels and increased with decrease in P levels. The maximum emergence m^{-2} were recorded where 20 kg K ha^{-1} and 40 kg P ha^{-1} were used. Our findings are in line with Gresta *et al*. (2019) who studied the impact of phosphorus fertilizer on yield related parameters in guar and found that phosphorus significantly increased emergence per meter square.

Table 01. Emergence m^{-2} of guar as affected by phosphorus and potassium

P (kg ha^{-1})	Potassium (kg ha^{-1})			
	20	**40**	**60**	**Mean**
40	55.3	53.3	53.3	54
80	53.7	51.3	49	51
120	53	54	53	53
Mean	54a	53ab	52b	
Control	40.3b			
Rest	52.9a			

Mean in row or column followed by same letters are not significantly different at P≤0.05 using LSD test. LSD value for phosphorous at P≥0.05=1.67, for Potassium=1.67 Interaction (P x K) = Ns, Control vs Rest=1.67

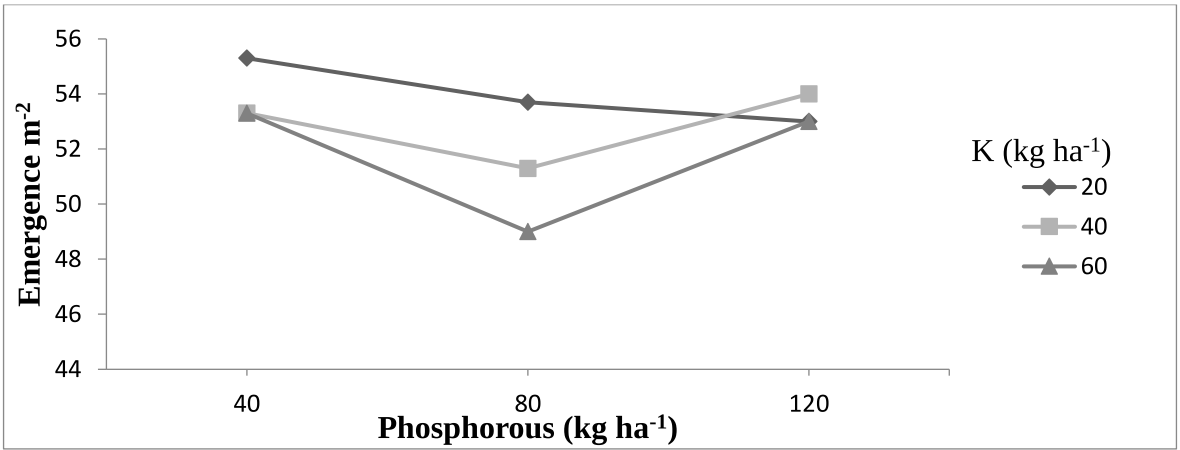

Figure 1. Emergence m^{-2} of guar as affected by phosphorus and potassium

Leaves Plant^{-1}: Statistical analysis of the data showed that potassium (K), phosphorous (P) and control Vs rest significantly affected the leaves plant^{-1}, while K x P interaction showed non-significant effect on leaves plant^{-1} (Table 02). Mean data shows that maximum leaves plant^{-1} (13.22) was recorded in treated plots and minimum leaves plant^{-1} (11.33) was observed in control plots. Among treatments more leaves (16) were recorded in higher levels of K (60 kg ha^{-1}) with P @ 120 kg K ha^{-1}. Same results were obtained by Ghaffarian *et al*. (2020) who assessed the physiological and morphological improvement among guar germplasm and indicated that leaves per plant are significantly enhanced under the influence of inorganic fertilizer and intercropping.

Table 02. Leaves plant^{-1} of guar as affected by phosphorus and potassium

P (kg ha^{-1})	Potassium (kg ha^{-1}) 20	40	60	Mean
40	13.00	12.00	14.00	13.00b
80	14.00	12.00	11.00	12.33c
120	14.00	13.00	16.00	14.33a
Mean	13.67	12.33	13.67	
Control	11.33 b			
Rest	13.22 a			

Mean in row or column followed by same letters are not significantly different at P≤0.05 using LSD test. LSD value for phosphorous at P≥0.05=Ns, for Potassium=0.5, for Interaction (P x K) =.4, for Control vs Rest=.6

Days to Pods Formation: Data regarding days to pods formation showed that phosphorous (P) and control vs. rest significantly affected days to pods formation, while P x K interaction and potassium (K) showed non-significant effect on days to pods formation (Table 03). More days to pod formation (67) was observed in control plots. Low level of P (40 kg ha^{-1}) required fewer days to pod formation (60). Days to pod formation increased with each increments of P and maximum days to pod formation (62) were noted at 120 kg P ha^{-1}. Thereafter, further increased in P did not enhance days to pod formation. Low level of K (20 kg ha^{-1}) resulted in fewer days to pod formation (60.1). Days to pod formation increased with each increment of K up to 60 kg K ha^{-1} (61.2). Thereafter, further increase in K did not enhanced days to pod formation. Interaction of P x K revealed that fewer days to pod formation (58.7) was recorded from 80 kg P x 40 kg K ha^{-1}, while maximum days to pod formation (63.3) was recorded from 120 kg P x 60 kg K ha^{-1} (Figure 2). Our results indicate that days to pod formation were increased with increase in P levels. The maximum days to pods formation were recorded where 120 kg P ha^{-1} were used. These results are in agreement with Pruitt (2021) who found that K significantly increases days to pod formation among guar genotypes in a study of soil and fertilizer management for guar cultivation.

Table 03. Days to pods formation of guar as affected by phosphorus and potassium

P (kg ha^{-1})	Potassium (kg ha^{-1}) 20	40	60	Mean
40	61.0	59.3	59	60b
80	59.3	58.7	61.3	60b
120	60.0	62.7	63.3	62a
Mean	60.1	60.2	61.2	

Control	67.0 a
Rest	60.52 b

Mean in row or column followed by same letters are not significantly different at P≤0.05 using LSD test. LSD value for phosphorous at P≥0.05=1.70, Potassium=Ns, Interaction (P x K) = Ns

For Control vs Rest=1.7

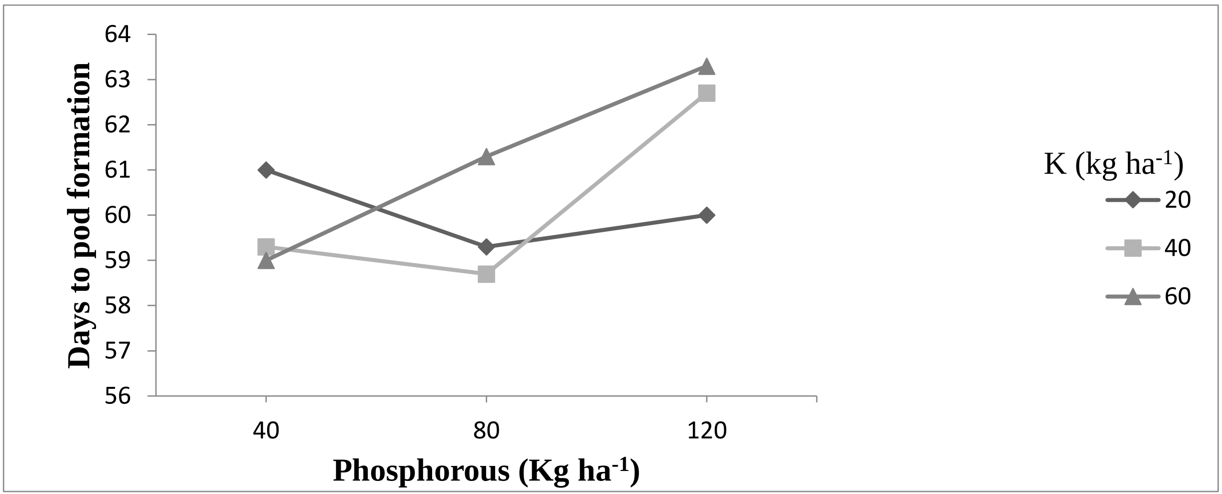

Figure 2. Days to pods formation of guar as affected by phosphorus and potassium

Pods Plant^{-1}: Statistical analysis of data revealed that potassium (K), P x K interaction and control vs. rest significantly affected pods plant^{-1}, while phosphorous (P) showed non-significant effects on pods plant^{-1} (Table 04). Among control vs rest more pods plant^{-1} (14) were observed in treated plots and less pods plant^{-1} (12) were recorded in control plots. Pods plant^{-1} increased with each increment of P and maximum pods plant^{-1} (16) were noted at 120 kg P ha^{-1}. Interaction between P x K revealed that more pods plant^{-1} (16) were recorded from 120 kg P x 60 kg K ha^{-}1. Due to more nutrition number of pod per plant increased, our findings are in line with El-Sawah *et al*. (2021) as they found more pods per plant in guar cultivars under the influence of growth promoters and inorganic fertilizers.

Table 04. Pods plant^{-1} of guar as affected by phosphorus and potassium

	Potassium (kg ha^{-1})			
Phosphorus (kg ha^{-1})	**20**	**40**	**60**	**Mean**
40	13.00	14.00	12.00	13.00
80	14.00	13.00	15.00	14.00
120	16.00	14.00	15.00	15.00

Mean	14.33	13.67	14.00
Control	12.00 b		
Rest	14.00 a		

Mean in row or column followed by same letters are not significantly different at P≤0.05 using LSD test. LSD value for phosphorous at P≥0.05=Ns, for Potassium=1.2, for Interaction (P x K) =1.4, for Control vs Rest=1.6

Thousand grain weight (g): Analysis of variance revealed that potassium (K), P x K interaction and control vs rest significantly affected thousand-grain weight, while phosphorous (P) showed non-significant effect on thousand-grain weight (Table 05). Low thousand grain weight (31.1 g) was observed in control plots. Low level of P (40 kg ha^{-1}) showed lower thousand grain weight (39.0 g). Thousand grain weight increases with each increment of P and maximum thousand grain weight (41.0 g) was noted at 80 kg P ha^{-1}. Thereafter, further increase in P did not enhanced thousand grain weight. Low level of K (20 kg ha^{-1}) showed lower thousand grain weight (38.77 g). Thousand grain weight increased with each increment of K and maximum thousand grain weight (42 g) was noted at 40 kg K ha^{-1}. Thereafter, further increase in K did not enhance thousand-grain weight. Interaction between P x K revealed that lesser thousand grain weight (35.7 g) was recorded from 80 kg P x 20 kg K ha^{-1}, while maximum thousand grain weight (44.7 g) was noted at 40 kg P x 40 kg K ha^{-1} (Figure 4). Thousand grain weights increased with increase in K levels. The maximum thousand-grain weight was recorded where 40 kg K ha^{-1} and 40 kg P ha^{-1} were used. The present findings are similar to that of Azizi *et al*. (2019) who found maximum1000- grain weight among guar genotypes as effected by phosphorus and potassium nutrients.

Table 05. Thousand-grain weight (g) of guar as affected by phosphorus and potassium

Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})			
	20	**40**	**60**	**Mean**
40	36.3	44.7	36.3	39
80	35.7	42.3	44.7	41
120	44.3	39	36	40
Mean	38.77b	42a	39ab	
Control	31.3 b			
Rest	40.0 a			

Mean in row or column followed by same letters are not significantly different at P≤0.05 using LSD test. LSD value for phosphorous at P≥0.05=Ns, for Potassium=3.64, for Interaction (P x K) = 3.64, for Control vs Rest=3.64

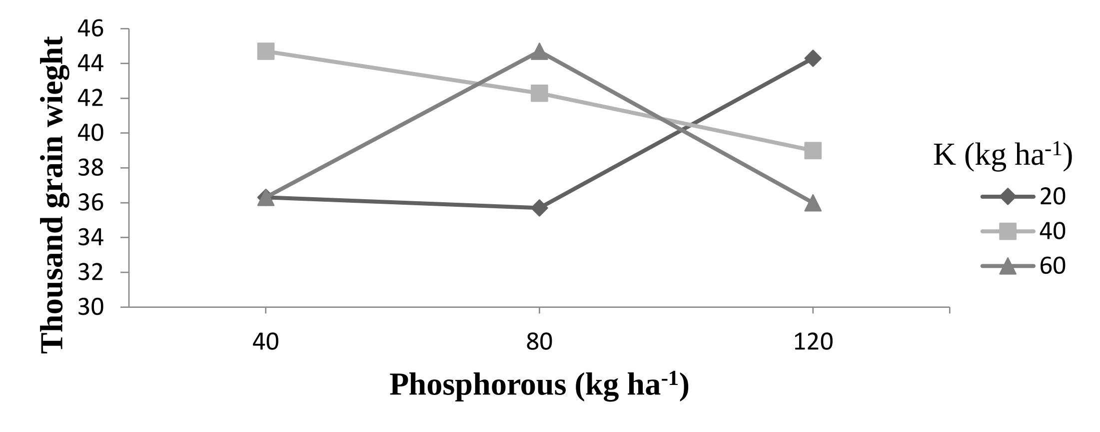

Figure 3. Thousand grain weight (kg ha^{-1}) of guar as affected by phosphorus and potassium.

Plant height (cm): Statistical analysis of data for plant height revealed that potassium (K), phosphorous (P), P x K interaction and control vs rest significantly affected plant height (cm). Low plant height (83.65 cm) was observed in control plots while more plant height (101.10 cm) was recorded in treated plots. Among P and K, plant height increased with increased levels of P and maximum plant height (101.60 cm) was recorded at 80 kg ha^{-1} for K more maximum height (106.27 cm) was noted at 60 kg K ha^{-1}. Our findings are in line with Pareek *et al*. (2022) who observed enhanced plant height under the influence of potassium fertilizer while evaluating guar for various physio-morphological traits under organic and inorganic fertilizer regimes.

Table 06. Plant height (cm) of guar as affected by phosphorus and potassium

	Potassium (kg ha^{-1})			
Phosphorus (kg ha^{-1})	**20**	**40**	**60**	**Mean**
40	88.64	101.20	100.71	96.85 c
80	100.60	102.32	103.25	102.06b
120	101.60	105.29	106.27	104.39a
Mean	96.95	102.94	103.41	101.10
Control	83.65 b			
Rest	101.10 a			

Mean in row or column followed by same letters are not significantly different at P≤0.05 using LSD test. LSD value for phosphorous at P≥0.05=Ns, for Potassium=5, for Interaction (P x K) =4, for Control vs Rest=6

Grain yield (kg ha^{-1}): Data regarding grain yield showed that potassium (K), phosphorous (P), P x K interaction and control vs rest significantly affected grain yield. Low grain yield

(974.6 kg ha^{-1}) was observed in control plots. Low level of P (40 kg ha^{-1}) showed low grain yield (1009 kg ha^{-1}). Grain yield increased with each increment of P enhanced grain yield and maximum grain yield (1120 kg ha^{-1}) was noted at 120 kg P ha^{-1}. Interaction between P x K reveled that minimum grain yield (1003) was observed at 40 kg P x 20 kg K ha^{-1}, while maximum grain yield (1149 kg ha^{-1}) was noted at 120 kg P x 60 kg K ha^{-1} (Figure 5). The maximum grain yield were recorded where 120 kg P ha^{-1} and 60 kg K ha^{-1} were used. This might be due to more mineral availability which increases the yield of crop. Our findings are in line with Gendy *et al*. (2013) who conducted an experiment on guar to check the influence of fertilizer and bio-fertilizer impact on guar varieties and noted that maximum yield was achieved through more application of K fertilizer.

Table 07. Grain yield (kg ha^{-1}) of guar as affected by phosphorus and potassium

	Potassium (kg ha^{-1})			
Phosphorus (kg ha^{-1})	**20**	**40**	**60**	**Mean**
40	1003	1011	1013	1009
80	1032	1065	1085	1061
120	1092	1120	1149	1120
Mean	1042 b	1065 ab	1082 a	
Control	974.667 b			
Rest	1063.00 a			

Mean in row or column followed by same letters are not significantly different at P≤0.05 using LSD test. LSD value for phosphorous at P≥0.05=Ns, for Potassium=22, for Interaction (P x K) =64, for Control vs Rest=86

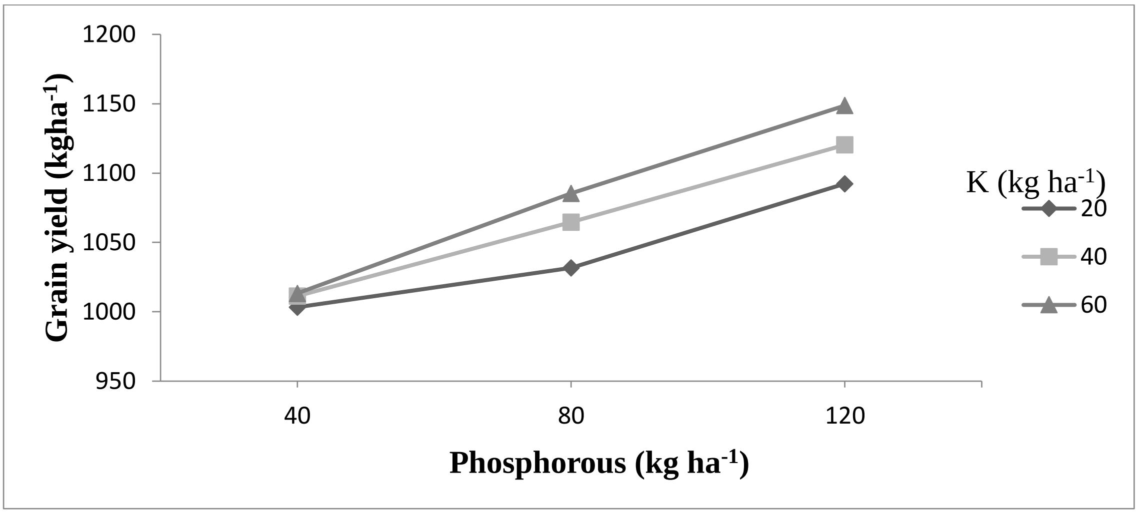

Figure 4. Grain yield (kg ha^{-1}) of guar as affected by phosphorus and potassium

CONCLUSION AND RECOMMENDATIONS

It is incurred from our results that using Phosphorus at the rate of 40 kg ha^{-1} and Potassium at the rate of 20 kg ha^{-1} increases yield and yield components of guar therefore they are recommended for general cultivation in agro-climatic conditions of Peshawar.

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