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GB Solanki
P.G. Scholar, College of Horticulture, S.D. Agricultural University, Jagudan, Mehsana, Gujarat, India

VR Chudasama
Associate Professor, College of Horticulture, S.D. Agricultural University, Jagudan, Mehsana, Gujarat, India

Mukesh Kumar
Assistant Professor, College of Horticulture, S.D. Agricultural University, Jagudan, Mehsana, Gujarat, India

PC Joshi
Associate Professor, C.P. College of Agriculture, S.D. Agricultural University, Sardarkrushinagar, Gujarat, India

FB Vani
P.G. Scholar, College of Horticulture, S.D. Agricultural University, Jagudan, Mehsana, Gujarat, India

SK Acharya
Assistant Professor, College of Horticulture, S.D. Agricultural University, Jagudan, Mehsana, Gujarat, India

Correspondence
Mukesh Kumar
Assistant Professor, College of Horticulture, S.D. Agricultural University, Jagudan, Mehsana, Gujarat, India

Effect of organic manures and biofertilizers application on growth of onion (*Allium cepa* L.)

GB Solanki, VR Chudasama, Mukesh Kumar, PC Joshi, FB Vani and SK Acharya

Abstract
An experiment was conducted at College of Horticulture, S.D. Agricultural University, Jagudan (Gujarat) during the year 2016-17 and laid out in factorial randomized block design with three replications. Sixteen treatment combinations comprising of four levels of biofertilizers *viz.*, PSB @ 1.25 lit/ha, *Azotobacter* @ 1.25 lit/ha, PSB @ 2.25 lit/ha and *Azotobacter* @ 2.25 lit/ha, two sources of organic manures *viz.*, 100% RDN through FYM and 100% RDN through neem cake and two methods of application *viz.*, soil application and seedling root dip method were assess under the study. The observations were recorded periodically on growth and available NPK status of soil. All the growth parameters were significantly affected by method of application, biofertilizers and organic manures treatments. Maximum plant height at 45 and 90 DAT, number of leaves per plant at 45 and 90 DAT, neck thickness at 45 and 90 DAT, days taken for maturity, minimum bolting per cent and available NPK status of soil after harvest were recorded with PSB @ 2.25 lit/ha applied as soil application and 100% RDN through FYM.

Keywords: Organic manures, biofertilizers, plant growth, plant height, number of leaves, bolting per cent, available NPK in soil

Introduction
Onion (*Allium cepa* L.) is the most important commercial vegetable crop and grown throughout the world including India. India is the second largest producer of onion in the world and occupies 1,320.00 thousand ha area with a production of 20,931.00 thousand MT and productivity 15.9 MT ha^{-1}. Maharashtra is leading state in terms of area and production, whereas Gujarat has maximum productivity (Anonymous, 2017) [2]. Onion is valued for its distinct pungent flavour and it is an essential ingredient for the cuisine of many regions. It is the queen of the kitchen (Selvaraj, 1976) [17]. The onion is preferred mainly because of its green leaves, immature and mature bulbs are either eaten raw or cooked or both. Mild flavoured or colourful bulbs are often chosen for salads. The bulbs are used in soups, sauces, condiments, spice, as medicine, seasoning of many foods and for the preparation of value added edible products like powder.

The onion crop is a highly nutrient responsive and the conventional methods of fertilization have undoubtedly helped in improving both bulb yield and quality. But lately, routine management practices appear to be incapable of maintaining yields over the long-term. The steady depletion of native soil fertility and the occurrence of multiple nutrient deficiencies in onion fields have led to the identification of nutrient management as a key limiting factor for sustainable onion production. Organic agriculture is gaining movement in India due to the health awareness among masses and to conserve environment. The important tenet of organic food movement that promotes ecological soundness and sustainable use of natural resources, also maintenance of crop diversity. The organic vegetable industry is flourishing due to consumer preference over traditionally grown vegetables, as a result an increase in varieties and selection of many vegetables in retail, supermarket and restaurants.

The farmyard manure (FYM) is one of the traditional organic manure for improving soils properties, either physical or chemical and biological besides conserving water holding capacity. Its effect may be directly in increasing crop yield by supplying some nutritional elements in available forms, or indirectly throughout biological decomposition (Marschener, 2012) [11].

Neem cake is the by-product obtained in the process of cold pressing of neem tree fruits and kernels. Solvent extraction process is used for *neem* oil. It is a potential source of organic manure, which contains 5.2% N, 1.1% P_2O_5 and 1.5% K_2O (Kanwar and Prihar, 1960) [17]. Besides nutrition, neem cake protects plant roots from nematodes, soil grubs and white ants probably due to its residual limonoid content.

Biofertilizers play an important role in increasing availability of nitrogen and phosphorus. They increase the biological fixation of atmospheric nitrogen and enhance phosphorus availability to the crop. Biofertilizers are carrier-based inoculates containing cells of efficient strains of specific microorganism used by farmers for enhancing the fertility of soil by fixing atmospheric nitrogen or by solubilizing soil phosphate or by stimulating plant growth for synthesis of growth promoting substances. Biofertilizers plays a key role for selective absorption of essential elements to plants. Uses of biofertilizers are being encouraged to save the chemical fertilizers and the environment (Karnan *et al*. 2012) [8].

Although many attempts have been made to study the role of organic manures and biofertilizers on onion crop, however, systematic fertilization of different organic manures for onion cultivation is needed particularly as the research work and technology on this aspect is very scanty under the study area.

Materials and Methods

The experiment was carried out in open field during *rabi* season, 2016-17 at College of Horticulture, S. D. Agricultural University, Jagudan, Dist. – Mehsana (Gujarat), India. The variety of onion was Agrifound Light Red under taken for investigation. Sixteen treatment combinations comprising of four levels of biofertilizers *viz.*, PSB @ 1.25 lit/ha, *Azotobacter* @ 1.25 lit/ha, PSB @ 2.25 lit/ha and *Azotobacter* @ 2.25 lit/ha, two sources of organic manures *viz.*,100% RDN through FYM and 100% RDN through neem cake and two methods of application *viz*., soil application and seedling root dip were applied under this study.

Methods of biofertilizers application

1. **Seedling Root Dip Method:** The biofertilizers were taken in liquid form and the required solution of *Azotobacter* and PSB were prepared @ 1.25 and 2.25 lit/ha, respectively. The required quantity of biofertilizers diluted in water and the roots of seedlings of onion were dipped for 30 minutes.
2. **Soil Application Method:** The required quantity of *Azotobacter* and PSB for the treatments were applied in to the soil before transplanting @ 1.25 and 2.25 lit/ha, respectively and before soil application of these biofertilizers mixed with FYM and neem cake as per requirement.

Observations

Plant Height: The plant height was measured in centimeter from the ground level to top of the plant with the help of meter scale. These observations were recorded at 45 and 90 days after transplanting and the average of ten tagged plants was worked out.

Number of leaves per plant: The total number of leaves per plant was counted at 45 and 90 days after transplanting. Finally an average number of leaves per plant were calculated at different stages of plant growth and average of ten tagged plants was worked out.

Plant neck thickness: The plant neck thickness was measured in centimeter with the help of Vernier callipers. These observations were recorded at 45 and 90 days after transplanting and average of ten tagged plants was worked out.

Days taken for maturity: Total number of days taken to attain physiological maturity of bulbs at 50-70 per cent neck fall stage was counted from date of transplanting from each treatment. The average days taken for maturity were worked out.

Bolting per cent: The number of bolters were counted from each treatment and worked out in per cent.

Soil Analysis: The soil samples were collected up to 30 cm depth with the help of auger before transplanting and after harvest of onion crop and processed for further analysis. The air dry and sieved soil samples were analyzed by standard methods *viz.*, alkaline $KMnO_4$ method, Olsen's method and flame photometric method for available nitrogen, phosphorus and potassium, respectively.

Results and Discussion

Growth parameters

The observations on the different growth parameters such as plant height (cm), number of leaves per plant and neck thickness (cm) at 45 and 90 days after transplanting, bolting per cent, days taken for maturity were recorded and analyzed to evaluate the treatments.

Plant height at 45 DAT: Effect of biofertilizers with organic manures and method of application and its interaction on plant height (cm) at 45 days after transplanting (DAT) are presented in Table 1. The data indicated that individual effect of biofertilizers with organic manures and method of application was found significant for plant height at 45 days after transplanting. The soil application of biofertilizers was recorded maximum plant height (27.17 cm).

An application of PSB @ 2.25 lit/ha recorded significantly maximum plant height (29.50 cm). This increase in plant height may be attributed to the decomposition of organic matter by microbial inoculants and thus releasing the available nutrients to the plants from the soil resulting ultimately in increase in growth of the plant. Additionally it may also be due to the fact that the efficiency of nitrogen might have increased in the presence of phosphorus. These results are in conformity with the findings of Gowda *et al.* (2007) [4] in garlic.

The application of 100% RDN through FYM recorded significantly maximum plant height (27.07 cm). An increase in plant height is due to addition of FYM which create sufficient pore space permitting adequate aeration for better seedling growth. The above results are in close accordance with Lal *et al.* (2002) [10] in onion.

The interaction effect between biofertilizers with organic manures and method of application was found not significant for plant height at 45 days after transplanting.

Plant height at 90 DAT: Effect of biofertilizers with organic manures and method of application and its interaction on plant height (cm) at 90 days after transplanting (DAT) are given in Table 1. The analyzed data indicated that individual effect of biofertilizers with organic manures and method of application on plant height at 90 days after transplanting was

found significant. Soil application of biofertilizers recorded significantly maximum plant height (61.23 cm).

An application of biofertilizers PSB @ 2.25 lit/ha recorded significantly maximum plant height (64.49 cm). These results are in close accordance with Kore *et al.* (2006) [9] who reported that the growth characters in respect of plant height was found maximum in the plants receiving nutrients from organic manures and biofertilizers.

The plant height (61.07 cm) was found maximum and significant with the application of 100% RDN through FYM. The height of plant is increases due to availability of optimum quantity of essential nutrients then resulting better photosynthesis. These findings are quite corroborating with the previous work of Singh and Sharma (2018) in onion.

The interaction effect between biofertilizers with organic manures and method of application was found not significant for plant height at 90 days after transplanting.

Table 1: Effect of biofertilizers with organic manures and method of application on plant height at 45 and 90 days after transplanting (DAT)

Method of application (M)	**Plant height (cm) at 45 DAT**	**Plant height (cm) at 90 DAT**
m_1 = Soil application	27.17	61.23
m_2 = Seedling root dip	25.93	58.53
S.Em.±	0.36	0.82
C.D. at 5%	1.05	2.36
Biofertilizers (B)		
b_1 = PSB @ 1.25 lit/ha	25.61	59.06
b_2 = *Azotobacter* @ 1.25 lit/ha	23.79	54.12
b_3 = PSB @ 2.25 lit/ha	29.50	64.49
b_4 = *Azotobacter*@ 2.25 lit/ha	27.30	61.85
S.Em.±	0.51	1.16
C.D. at 5%	1.48	3.34
Organic manures (F)		
f_1 = 100% RDN through FYM	27.07	61.07
f_2 = 100% RDN through neem cake	26.02	58.69
S.Em.±	0.36	0.82
C.D. at 5%	1.05	2.36
C.V.%	6.70	6.69

Interaction of Plant height (cm) at 45 DAT				
Interaction	M x B	M x F	B x F	M x B x F
S.Em.±	0.73	0.51	0.73	1.03
C.D. at 5%	NS	NS	NS	NS

Interaction of Plant height (cm) at 90 DAT				
Interaction	M x B	M x F	B x F	M x B x F
S.Em.±	1.64	1.16	1.64	2.31
C.D. at 5%	NS	NS	NS	NS

Number of leaves per plant at 45 DAT: Effect of biofertilizers with organic manures and method of application and its interaction on number of leaves per plant at 45 days after transplanting are presented in Table 2. The perusal of data indicated that individual effect of biofertilizers with organic manures and method of application was found significant for number of leaves per plant at 45 days after transplanting. Soil application of biofertilizers recorded significantly maximum number of leaves per plant (4.81).

Maximum number of leaves per plant (4.98) was recorded with PSB @ 2.25 lit/ha and it was significantly at par with *Azotobacter* @ 2.25 lit/ha (4.78). Rodriguez and Fraga (1999) [15] reported the role of phosphorus in vegetative growth plants. In general, PSB @ 1 lit/ha along with different phosphorus levels gave maximum number of leaves per plant. Nantha and Veeraragavathatham (2000) [13] also observed increased in growth parameters with combined application of inorganic and biofertilizers in brinjal.

The application of 100% RDN through FYM recorded significantly maximum number of leaves per plant (4.80) at 45 DAT. Application of organic manures promotes microbial population and their activity and also provide nutrients which helps to initiate various growth promoting activities, resulting vigorous growth of plants. The onion plants nourished with inorganic fertilizers (N, P and K) and organic fertilizers gave maximum values in growth parameters, this boosted vegetative growth might be due to ensured higher number of green leaves. Similar results have been reported by Yadav *et al.* (2003) [21] in onion and Chettri and Thapa (2005) [3] in potato.

The interaction effect between biofertilizers with organic manures and method of application was found not significant for number of leaves per plant at 45 days after transplanting.

Number of leaves per plant at 90 DAT: Effect of biofertilizers with organic manures and method of application and its interaction on number of leaves per plant at 90 days after transplanting (DAT) is given in Table 2. The results indicated that individual effect of biofertilizers with organic manures and method of application was found significant for number of leaves per plant at 90 days after transplanting.

The analyzed data showed that significantly maximum number of leaves per plant (9.58) was observed with soil application of biofertilizers.

The application of PSB @ 2.25 lit/ha was recorded maximum number of leaves per plant (9.98) which was at par with *Azotobacter* 2.25 @ lit/ha (9.53). The increase in number of leaves might be due to the combined application of organic manures and biofertilization as the higher absorption of nutrients that helps in enhancement cell division, cell elongation and thus concomitant increase in metabolic activity. Similar results were also observed by Vivek *et al.* (2001) [20] in potato.

The significant maximum number of leaves per plant (9.54) was found with the application of 100% RDN through FYM, whereas at par with 100% RDN through neem cake (9.03).

Probable reasons for number of leaves, may be attributed to the promotive effects of integrated nutrient management on vegetative growth which ultimately lead to more photosynthetic activities. These findings in line with the findings of Jayathilake *et al.* (2002) [5], Jayathilake *et al.* (2003) [6] and Mondal *et al.* (2004) [12] in onion.

The interaction effect between biofertilizers with organic manures and method of application was found not significant for number of leaves per plant at 90 days after transplanting.

Table 2: Effect of biofertilizers with organic manures and method of application on number of leaves per plant at 45 and 90 days after transplanting (DAT)

Method of application (M)	**Number of leaves per plant at 45 DAT**	**Number of leaves per plant at 90 DAT**
m_1 = Soil application	4.81	9.58
m_2 = Seedling root dip	4.59	8.99
S.Em.±	0.06	0.12
C.D. at 5%	0.17	0.34
Biofertilizers (B)		
b_1 = PSB @ 1.25 lit/ha	4.62	9.09
b_2 = *Azotobacter* @ 1.25 lit/ha	4.41	8.54
b_3 = PSB @ 2.25 lit/ha	4.98	9.98
b_4 = *Azotobacter* @2.25 lit/ha	4.78	9.53
S.Em.±	0.08	0.17
C.D. at 5%	0.24	0.48
Organic manures (F)		
f_1 = 100% RDN through FYM	4.80	9.54
f_2 = 100% RDN through neem cake	4.59	9.03
S.Em.±	0.06	0.12
C.D. at 5%	0.17	0.34
C.V.%	6.02	6.26

Interaction for Number of leaves per plant at 45 DAT				
Interaction	M x B	M x F	B x F	M x B x F
S.Em.±	0.12	0.08	0.12	0.16
C.D. at 5%	NS	NS	NS	NS

Interaction for Number of leaves per plant at 90 DAT				
Interaction	M x B	M x F	B x F	M x B x F
S.Em.±	0.24	0.17	0.24	0.34
C.D. at 5%	NS	NS	NS	NS

Neck thickness at 45 DAT: Effect of biofertilizers with organic manures and method of application and its interaction on neck thickness at 45 days after transplanting are presented in Table 3. The data indicated that individual effect of biofertilizers with organic manures and method of application was found significant for neck thickness at 45 days after transplanting.

The revealed from the data significantly maximum neck thickness (0.65 cm) was observed with soil application of biofertilizers, while the significant and maximum neck thickness (0.72 cm) was recorded with the application of PSB @ 2.25 lit/ha. The increase in neck thickness may be due to increase in neck length and neck width with PSB application. PSB increases the supply of mineral nutrients by the establishment of mycorrhizal symbiosis particularly of those nutrients whose ionic forms have poor mobility in the soil solution. The present results corroborated with the findings of Smith and Read (1997).

The data further showed that significant and maximum neck thickness (0.65 cm) was found with the application of 100% RDN through FYM. It might be due to the presence of macro as well as micro nutrients in FYM that helps in balance uptake of essential plant nutrients. The obtained results are in line with the findings of Jayathilake *et al.,* (2002) [5] in onion.

The interaction effect between biofertilizers with organic manures and method of application was found not significant for neck thickness at 45 days after transplanting.

Neck thickness at 90 DAT: Effect of biofertilizers with organic manures and method of application and its interaction on neck thickness at 90 days after transplanting (DAT) is presented in Table 3. The data indicated that individual effect of biofertilizers with organic manures and method of application was found significant for neck thickness at 90 days after transplanting.

The data showed that application of biofertilizers in soil recorded significantly maximum neck thickness (1.42 cm), whereas PSB applied @ 2.25 lit/ha was found maximum and significant effect on neck thickness (1.44 cm). The increase in neck thickness with application of biofertilizers increase might be due to optimum growth of plants which enhanced by the production of bioactive substances having similar effect as that of growth regulators besides nitrogen fixation through biofertilizers. These results are closely related with the earlier findings of Amrithalingam (1988) in chilli and Parvatham and Vijayan (1989) [14] in okra.

Data further showed that the application of 100% RDN through FYM recorded significantly maximum neck thickness (1.42 cm). It might have accelerated the metabolic and physiological activity of the plant due to presence of micro and macro nutrients. Increase in neck diameter with application of manures and biofertilizers are in close agreement with the findings of Samavant *et al.,* (2001) [16] in tomato.

The interaction effect of biofertilizers with organic manures and method of application was found not significant for neck thickness at 90 days after transplanting.

Table 3: Effect of biofertilizers with organic manures and method of application on neck thickness at 45 and 90 days after transplanting (DAT)

Method of application (M)	Neck thickness at 45 DAT (cm)	Neck thickness at 90 DAT (cm)
m_1 = Soil application	0.65	1.42
m_2 = Seedling root dip	0.62	1.34
S.Em.±	0.01	0.02
C.D. at 5%	0.02	0.05
Biofertilizers (B)		
b_1 = PSB @ 1.25 lit/ha	0.62	1.32
b_2 = *Azotobacter* @ 1.25 lit/ha	0.54	1.22
b_3 = PSB @ 2.25 lit/ha	0.72	1.55
b_4 = *Azotobacter* @ 2.25 lit/ha	0.66	1.44
S.Em.±	0.01	0.03
C.D. at 5%	0.03	0.07
Organic manures (F)		
f_1 = 100% RDN through FYM	0.65	1.42
f_2 = 100% RDN through neem cake	0.62	1.34
S.Em.±	0.01	0.02
C.D. at 5%	0.02	0.05
C.V.%	6.19	6.33

Interaction for Neck thickness at 45 DAT (cm)				
Interaction	M x B	M x F	B x F	M x B x F
S.Em.±	0.02	0.01	0.02	0.02
C.D. at 5%	NS	NS	NS	NS
Interaction Neck thickness 90 DAT (cm)				
Interaction	M x B	M x F	B x F	M x B x F
S.Em.±	0.04	0.03	0.04	0.05
C.D. at 5%	NS	NS	NS	NS

Bolting Per cent: Effect of biofertilizers with organic manures and method of application and its interaction on bolting per cent is given in Table 4. The results showed that individual effect of biofertilizers with organic manures and method of application was found significant for bolting per cent.

The analyzed data indicated that soil application of biofertilizers recorded significantly minimum bolting per cent (0.81). Furthermore, the significantly minimum bolting per cent 0.51 and 0.85 was recorded with the application of PSB @ 2.25 lit/ha and 100% RDN through FYM, respectively. Whereas, the interaction effect between biofertilizers with organic manures and method of application was found not significant for bolting per cent.

Days taken for Maturity: Effect of biofertilizers with organic manures and method of application and its interaction on days taken for maturity are presented in Table 4. The results indicated that individual effect of biofertilizers with organic manures and method of application was found not significant for days taken for maturity.

The interaction effect between biofertilizers with organic manures and method of application was found not significant for days taken for maturity.

Table 4: Effect of biofertilizers with organic manures and method of application on bolting per cent and days taken for maturity of onion

Method of application (M)	Bolting per cent	Days taken for maturity
m_1 = Soil application	0.81	128.14
m_2 = Seedling root dip	0.97	128.42
S.Em.±	0.02	0.46
C.D. at 5%	0.07	NS
Biofertilizers (B)		
b_1 = PSB @ 1.25 lit/ha	0.98	128.50
b_2 = *Azotobacter* @ 1.25 lit/ha	1.29	128.28
b_3 = PSB @ 2.25 lit/ha	0.51	128.09
b_4 = *Azotobacter*@ 2.25 lit/ha	0.79	128.25
S.Em.±	0.03	0.65
C.D. at 5%	0.09	NS
Organic manures (F)		
f_1 = 100% RDN through FYM	0.85	128.35
f_2 = 100% RDN through neem cake	0.93	128.21
S.Em.±	0.02	0.46
C.D. at 5%	0.07	NS
C.V.%	12.73	1.77

Interaction for bolting per cent				
Interaction	M x B	M x F	B x F	M x B x F
S.Em.±	0.05	0.03	0.05	0.07
C.D. at 5%	NS	NS	NS	NS
Interaction for days taken for maturity				
Interaction	M x B	M x F	B x F	M x B x F
S.Em.±	0.93	0.65	0.93	1.31
C.D. at 5%	NS	NS	NS	NS

Available nitrogen, phosphorus and potassium in soil: Effect of biofertilizers with organic manures and method of application and its interaction on available nitrogen, phosphorus and potassium status in soil before and after harvest of onion is presented in Table 5. The results revealed that individual effect of biofertilizers with organic manures and method of application was found not significant for available nitrogen phosphorus and potassium in soil at after harvest of test crop. Moreover, the interaction effect between biofertilizers with organic manures and method of application was found not significant for available nitrogen, phosphorus and potassium status in soil at after harvest of onion.

Table 5: Effect of biofertilizers with organic manures and method of application on available nitrogen, phosphorus and potassium status in soil before and after harvest of test crop

		Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
Before		185.00	32.00	262.00
After				
Method of application (M)				
m_1 = Soil application		177.95	31.08	273.89
m_2 = Seedling root dip		177.34	30.84	272.76
S.Em.±		1.28	0.23	2.07
C.D. at 5%		NS	NS	NS
Biofertilizers (B)				
b_1 = PSB @ 1.25 lit/ha		177.04	30.66	271.60
b_2 = *Azotobacter* @ 1.25 lit/ha		175.74	30.35	270.59
b_3 = PSB @ 2.25 lit/ha		179.34	31.67	277.36
b_4 = *Azotobacter*@ 2.25 lit/ha		178.45	31.15	273.74
S.Em.±		1.81	0.32	2.93
C.D. at 5%		NS	NS	NS
Organic manures (F)				
f_1 = 100% RDN through FYM		177.78	31.01	273.56
f_2 = 100% RDN through neem cake		177.50	30.90	273.08
S.Em.±		1.28	0.23	2.07
C.D. at 5%		NS	NS	NS
C.V.%		3.52	3.61	3.71
Interaction for Available Nitrogen in soil				
Interaction	M x B	M x F	B x F	M x B x F
S.Em.±	2.55	1.81	2.55	3.61
C.D. at 5%	NS	NS	NS	NS
Interaction for Available Phosphorus in soil				
Interaction	M x B	M x F	B x F	M x B x F
S.Em.±	0.46	0.32	0.46	0.65
C.D. at 5%	NS	NS	NS	NS
Interaction for Available Potassium in soil				
Interaction	M x B	M x F	B x F	M x B x F
S.Em.±	0.46	0.32	0.46	0.65
C.D. at 5%	NS	NS	NS	NS

Conclusion

The results of the present study reflected that the application of PSB @ 2.25 lit/ha applied as soil application and 100% RDN through FYM have significant effects on all the growth parameters of onion crop studied.

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