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Enhancing Lentil Productivity in the North-West Alluvial Plain Zone through Cluster Front Line Demonstration (CFLD)

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ABSTRACT: Lentil is predominantly a rainfed Rabi crop that grows in a constrained environment. Enhancing lentil productivity through the implementation of suitable location specific technologies with timely and careful management. It is the second most important winter legume crop in India. It can be easily grown under residual soil moisture conditions without further irrigation in large fallow areas in India just after the *Kharif* rice harvest (previous crop). But lentil production is low in the North-West Alluvial Plain Zone (NWAPZ) because of the availability of quality seed and lack of knowledge of advanced technology to produce crops. The results clearly revealed that the average yield of lentil under cluster front line demonstrations was registered of 1424 kg ha^{-1} as compared to 1000 kg ha^{-1} recorded in farmers' practice; average yield increase of 37.28 percent over the farmers' practices. Average net returns of Rs. 33,772.00 ha^{-1} relative to farmers' practices (Rs.19, 037.00 ha^{-1}) were obtained, and average BCR of 2.35 and 1.84 have been registered in demonstrated plots and farmer's practices, respectively. It was found that the mean technological gap, extension gap, and technological index were 196 kg ha^{-1}, 425 kg ha^{-1} and 12%, respectively.

Keywords: BCR, Demonstration, Extension, Farmers, Lentil, Productivity, Yield.

INTRODUCTION

Lentil (*Lens culinaris*) is one of the most ancient crop among the legumes, which occupies an area of 1.42 m ha with an annual production of 1.32 million ha with a production of 1.18 million tons and productivity of 894 kg ha^{-1} (Directorate of Economics and Statistics, 2020). Lentil ranks fifth in the global pulse production with varying yield potential between 850 to 1100 kg ha^{-1} (Williams *et al.* 1993; Carman, 1996). In India, the main lentil-growing states are Uttar Pradesh (38.47%), Madhya Pradesh (29.95%), West Bengal (13.88%) and Bihar (10.26%) respectively. Lentils are a relatively condense moisture-tolerant crop *i.e.*, grown all over the world, particularly in Canada, Turkey, USA, Australia and India that contributes to more than three-fourths of global lentil production (Alexander, 2015). Lentil can be successfully grown under low soil fertility and reduced moisture conditions (Saoub *et al.*, 2010). The lentil is a "clean crop", relatively free of anti-nutritional factors, low in flatulence, as well as have low post-prandial glycemic index that is good for diabetes persons. It has low levels of methionine and cystine, an excellent source of protein and amino acids to meet the nutritional needs of developing countries (Bhatty, 1988). Lentils have the second-highest protein-to-calorie ratio of all legumes after soybean. Many researchers reported diverse proximate composition of lentil seeds *i.e.*, presented in Tables 1 & 2 (Urbano *et al.*, 2007). Lentils are rich in protein content (21–31%) and carbohydrate (62–69%), of which the majority is starch (Adsule *et al.*, 1989). It is reported that lentil protein contains all the essential amino acids; however, like other legumes, it is limited in sulphur amino acids, threonine and tryptophan (Shekib *et al.*, 1986). Lentils are typically high in micronutrients and have the potential to provide adequate amounts of food, especially iron (Fe), zinc (Zn) and selenium (Se) (Swargiary *et al.*, 2021).

It plays a significant role as a rotational crop by improving soil organic matters, soil nutritional status and microbial status in the soil (Erskine *et al.*, 2011). Lentil straw is an important animal feed because of its easy digestibility, and rich in protein, calcium, and phosphorous contents, while being low in cellulose as compared to wheat straw, as well as being highly palatable in nature (Erskine *et al.*, 1990). As being leguminous crop, it adds nitrogen, carbon, and organic matter to the soil, thus ensuring the sustainability of cereal-based cropping systems. However, conducted a demonstration of improved varieties and technologies of lentils and found a yield advantage of approximately 33 percent over local control (Kokate *et al.*, 2013). Therefore, Krishi Vigyan Kendra (KVKs), a huge ICAR network in our country, can play a crucial role in the demonstration of improved crop production technologies in farmers' fields with the objectives to minimize the problem of poor lentil yield, to increase lentil area, production, and productivity in the North Western Alluvial Plain (NWPA) area, and to enhance the economic benefits of both farmers and the soil.

MATERIALS AND METHODS

The present CFLD experiment was carried out during *Rabi* season for five consecutive years from 2015-16 to 2019-20, in different sits of selected cluster villages in Muzaffarpur district, Bihar. Altogether, 249 lentil crop growers were selected for successful demonstration of lentil yield performance in the eight blocks, *viz.*, Saraiya, Paru, Kudhani, Bandara, Motipur, Madwan, Kanti and Sakara which come under the jurisdiction of Krishi Vigyan Kendra, Saraiya, Muzaffarpur affiliated with Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar (India). During five years of study, an area of 104 ha was covered with plots of 0.40 ha each under cluster front line demonstration (Fig. 1). Before conducting CFLDs, the farmers were selected and details about the farmer's preparation for specific training and group discussion regarding good package and practices of crop production have been depicted in Tables 1 & 2, as well as the gap between technological interventions and existing farmer practise. In general, the soils of the study area are sandy loam, with soil status revealed in Figs. 2-12. The high-yielding variety HUL-57 was demonstrated at farmers' fields with a full package of practises, *viz.*, proper seed rate, sowing at a distance of 30cm × 10cm, soil test-based fertilizer, weed management, and improved plant protection measures. Demonstration control plots were also kept where farmer's practises were carried out (Table 4). Seed was treated with *Rhizobium* culture @ 2 gm kg^{-1}, carbendazim @ 1 g kg^{-1} and insecticide, *i.e.*, chloripyriphos @ 8 g kg^{-1} seed, to check the attack of insects like termites. The recommended doses of fertilizer were applied @20 kg ha^{-1}nitrogen, 40kg ha^{-1} P_2O_5, 20kg ha^{-1} K_2O and 15 kg ha^{-1} $ZnSO_4$ as basal application. In general, growers do not use nitrogen fertilizers for lentil production. For weed management, pendimethalin P.E. @ 1.5 kg a.i. ha^{-1} was applied just after sowing for initial weed management (Table 4). Visits by farmers and extension functionaries were organized at demonstration plots to disseminate the message on a large scale. The technology demonstrations among farmers during field operations such as sowing, fertilization, insect-pest and disease management, weed management, harvesting, etc. by trainings and field visits. Traditional practises were performed when local controls were carried out. Harvesting may be done manually in late spring and early summer, kept dry in fields for 2 to 3 days, and subsequently beaten by threshing of dried plants with heavy sticks. Lentil seed maintained 9–10% moisture at the time of storage. The data output was collected from both CFLD plots as well as control plots (farmers practices), and finally yield and gap analysis, along with the economic parameters, were computed and analyzed on different parameters using the following formula as given below:

$$\text{Yield increase (\%)} = \frac{\text{Demonstrated Yield} - \text{farmers Practise Yield}}{\text{Farmers Practise Yield}} \times 100$$

$$\text{Technology gap} = \text{Potential Yield} - \text{Demonstrated Yield}$$

$$\text{Extension gap} = \text{Demonstrated Yield} - \text{farmers Practise Yield}$$

$$\text{Technology index(\%)} = \frac{\text{Potential Yield} - \text{Demonstrated Yield}}{\text{Potential Yield}} \times 100$$

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross returns (Rs. ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs. ha}^{-1}\text{)}}$$

RESULTS AND DISCUSSION

A. Yield

The data showed that the percentage increase in demonstration grain yield relative to farmers' practices ranged from 30.25 to 43.37, with an average 37.28 per cent yield advantage under CFLD in comparison to farmers practice (FP) of lentil cultivation. Biomass and seed yield closely depend on the nitrogen fixation capacity of the genotype in terms of nitrogen (N) requirements, which are particularly important during the reproductive growth of lentil (Sinclair and de Wit, 1975). Many scientists also reported a wide yield gap of 30-105 per cent with an average value of 42 per cent in various production zones of India (Reddy and Reddy 2010; Ali and Gupta 2012). The study showed a gap between the existing and intervention technologies in the cultivation of lentil crops in Muzaffarpur district of North Bihar under calcareous soil (Table 4). The wide gap in potential yield was recorded in cases of variety, seed treatment, spacing, fertilizer dose, and foliar spray and a partial gap was observed in seed rate, time of sowing and plant protection, respectively, because farmers were not very aware of new technologies. In the study area, farmers commonly use local or old varieties/ cultivars in place of the recommended high-yielding varieties. The major reasons for the unavailability of seeds are time and a lack of knowledge. Similarly, the gap in lentil productivity is due to improper dissemination of advanced technologies, including IPM, IDM, INM, negligible seed replacement with high-yielding varieties, and the non-availability of quality certified seeds (Sharma and Shukla 2014).

B. Technology gap, Extension gap and Technology Index

The study obtained a wide gap in technology during five years (2015-16 to 2019-20) (Table 5). It was found that the lowest (41 kg ha^{-1}) during 2018-19 was the highest (375 kg ha^{-1}) during 2016-17 with an average technology gap of 196 kg ha^{-1}. The difference in the technological gap in different years may be due to the differential feasibility of the recommended technologies. Similarly, in the case of an extension gap, it ranged from 325 to 566 kg ha^{-1} found between CFLD and farmers practices in different study years, with an average extension gap of 425 kg ha^{-1} (Table 5). The lowest (325 kg ha^{-1}) extension gap was recorded in 2016–17, whereas the highest (566 kg ha1) was recorded in 2018–19. This difference could be attributed to the adoption of advanced technology in demonstrations that leads to higher grain yields than farmers' practices. The technological gap can be attributed to dissimilarities in soil nutrient status, local climate conditions, varietal adaptability, and the adoption of technological practices. The extension gap indicates the need to trained farmers in various extension approaches for better technology adoption. A similar finding was also reported by Singh *et al.* (2022).

In the case of the technology index for all the year-wise demonstrations as per the technology gap. Results indicating a higher technology index reflected inadequate technology or a lack of extension services for technology transfer to the farmer's field. Results also corroborate findings from Singh (2015). He stressed the need to educate farmers in different ways to accept improved and sustainable production technologies in order to reverse this trend (Raj *et al*., 2013).

C. Economic Parameters

The economics of the study were calculated and depicted as different variables used in cultivation influencing the cost of production, like seed, bio-fertilizers, fungicides, and insecticides, for CFLD demonstrations in addition to use by the farmers. It is noted that an average additional investment of Rs. 14735 ha^{-1} was made under CFLD demonstrations (Table 6). However, the variation in economic returns obtained is associated with the grain yield and minimum support price (MSP) or sailing price, which varied from year to year. A maximum additional return of Rs. 16214 ha^{-1} was obtained during the year 2019–20 due to higher grain yield. Higher additional returns in demonstrations could be due to better technology, non-monetary factors, timely agronomical practices, and systematic monitoring. The lowermost and uppermost benefit cost ratios (BCR) were 2.05 and 2.57 in 2018–19 and 2016–17, respectively. Chaudhary *et al*. (2018) also reported similar findings. The observed variation in crop yield may be attributed to differences in soil fertility and meteorological conditions. Kumar *et al.* (2019); Singh *et al.* (2020) also reported higher monetary returns and a B:C ratio as a result of improved pulse production technologies.

D. Constraints

Farmers have identified access to credit as a limitation and a lack of understanding of the application and practice of suggested agronomic practices. The reported constraints were as follows:

- Lack of improved variety and quality seed
- Lack of knowledge of suitable management practices to obtain good performance.
- Pests and diseases (particularly wilt disease).
- Men power (labour) availability.
- Nature occurrence.

Table 1: Chemical composition of lentil (per 100 g of dry matter).

Particulars	Range
Energy (Kcal)	1483-2010
Total nitrogen (g)	3.72-4.88
Protein (Nx6.25)(g)	20.6-31.4
Non-protein nitrogen (g)	0.49-1.049
Fat(g)	0.7-4.3
Dietary fiber (g)	17
Carbohydrates(g)	43.4-69.9
Fiber (g)	5.0-26.9
Ash (g)	2.2-4.2

Source: Urbano *et al.*(2007).

Table 2: Essential amino acid composition of lentil protein (mg g^{-1} of protein).

Amino Acids	Content
Lysine	362-481
Threonine+Glutamic acid	1049-1370
Methionine+Valine	294-442
Phenylalanine	272-410
Leucine+Isoleucine	500-611
Histidine	138-167
Tryptophan	7-10

Source: Shekib *et al.*(1986); Wang and Daun (2006)

Table 3: Details of need-based inputs given on CFLD of lentil.

Years	No. of demonstration	Variety	Technology demonstrated	Need based inputs
2015-16	44	L-4594	Soil test, Improved variety, INM and IPM	Seed, *Rhizobium*, PSB, Boron and Mancozeb 63% + carbendazim 12%
2016-17	100	HUL-57	Soil test, Improved variety, INM and IPM	Seed, *Rhizobium*, PSB and Mancozeb 63% + carbendazim 12%
2017-18	25	HUL-57	Soil test, Improved variety, INM and IPM	Seed, *Rhizobium*, PSB, Micronutrient mixture (liquid) and Neem oil
2018-19	25	HUL-57	Soil test, Improved variety, INM and IPM	Seed, *Rhizobium*, PSB, Sulphur, Boron, Micronutrient mixture (liquid) and Mancozeb 63% + carbendazim 12%
2019-20	63	HUL-57	Soil test, Improved variety, INM and IPM	Seed, *Rhizobium*, PSB, Sulphur, Micronutrient Mixture (Liqude), Neem Oil and Mancozeb 63%+ carbendazim 12%

Table 4: Compression between technology intervention and existing farmers practise under CFLD on lentil.

Particular	Technology intervention	Existing farmers practise	Gap in adoption
Variety	Improved variety HUL-57	Local/ won seed	Full gap
Seed rate	45 kg ha^{-1}	50 kg ha^{-1}	Partial gap
Seed treatment	Carbendazim @ 3gm kg^{-1} seed and *Rhizobium* & PSB Culture @ 200gm/ 10 kg seed	No seed treatment	Full gap
Time of sowing	15th October to 15th November		Partial gap
Spacing	30cm × 10cm	Broadcasting	Full gap
Fertilizer dose	20 kg N: 40kg P_2O_5: 20kg K_2O: 15 kg Zn SO_4 as basal application	Only 30 kg P_2O_5	Full gap
Foliar spray	Micronutrient mixture @ 2.5 ml $litre^{-1}$ at flowering initiation stage	No micronutrient use	Full gap
Weed control	One weeding 20-25 days after sowing	One weeding	No gap
Plant protection	Monitoring of aphid at vegetative stage control by spray neem oil 2.5 ml $lit.^{-1}$ and wilt control through carbendazim 63% & mancozeb 12% @ 1.5 g $litre^{-1}$	Use insecticide only	Partial gap

Table 5: Impact of Productivity, technology gap, extension gap, and technology index of lentil crop under CFLD.

Years	Area (ha)	No. of Demo.	Demo. Variety	Yield ($kgha^{-1}$)			% increased Over FP	Technology gap (kg ha^{-1})	Extension gap (kg ha^{-1})	Technology index (%)
				Potential	Demo.	FP				
2015-16	24	44	L-4594	1700	1423	1069	33.87	277	354	16.29
2016-17	40	100	HUL-57	1600	1225	900	36.11	375	325	23.44
2017-18	10	25	HUL-57	1600	1557	1086	30.25	043	471	02.69
2018-19	10	25	HUL-57	1600	1559	993	43.37	041	566	02.56
2019-20	20	63	HUL-57	1600	1357	950	42.82	243	407	15.19
Total/ Average	**104**	**249**	**-**	**-**	**1424**	**1000**	**37.28**	**196**	**425**	**-**

Table 6: Impact of CFLD on grass cost, gross return, net return and BCR of lentil crop.

Particulars	Improved package & practice						Local farmer practise					
	2015-16	2016-17	2017-18	2018-19	2019-20	Mean	2015-16	2016-17	2017-18	2018-19	2019-20	Mean
Cost of cultivation (Rs. ha^{-1})	22575	23800	29517	26490	24500	**24975**	21550	22000	24682	22550	22500	**21550**
Yield (kg ha^{-1})	1423	1225	1557	1559	1357	**1424**	1069	900	1086	993	950	**1000**
Gross income (Rs.ha^{-1})	56920	61250	62280	54565	60726	**58288**	42760	30000	43440	34755	42512	**38005**
Net income (Rs. ha^{-1})	34345	37450	32763	28075	36226	**33313**	21210	23000	18758	12205	20012	**18749**
Additional Net returns	13135	14450	14005	15870	16214	**14735**	-	-	-	-	-	-
BCR	2.52	2.57	2.11	2.05	2.48	**2.33**	1.98	2.04	1.76	1.54	1.89	**1.76**

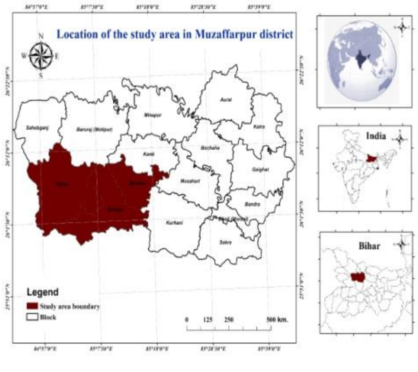

Fig. 1. Location map of the study area.

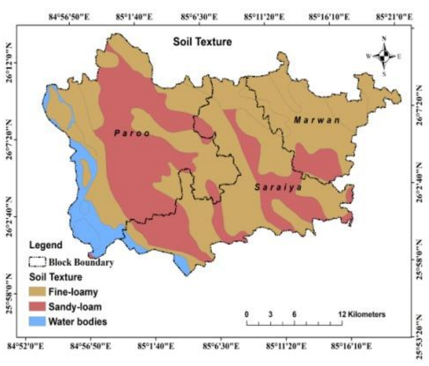

Fig. 2. Physical properties of the area.

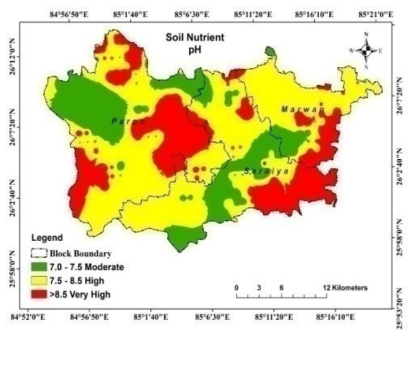

Fig. 3. Soil pH of the study area.

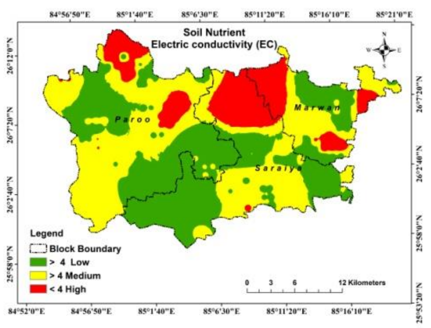

Fig. 4. Soil EC of the study area.

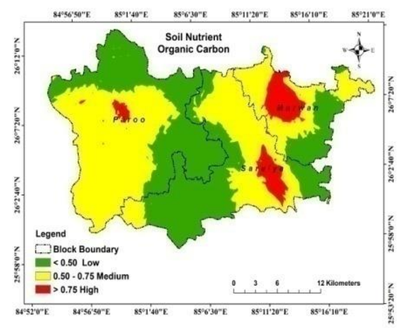

Fig. 5. Soil organic carbon (%).

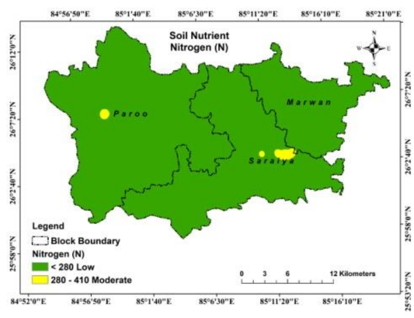

Fig. 6. Soil available nitrogen kg ha^{-1}.

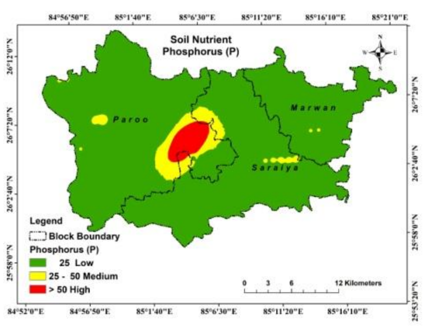

Fig.7. Soil available phosphorus kg ha^{-1}

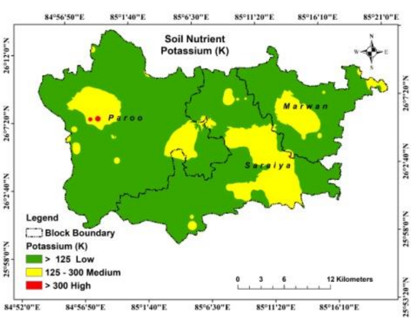

Fig. 8. Soil available potassium kg ha^{-1}

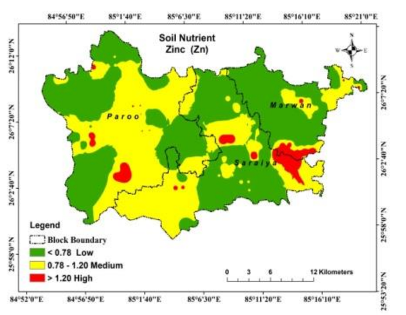

Fig. 9. Soil available Zn ppm.

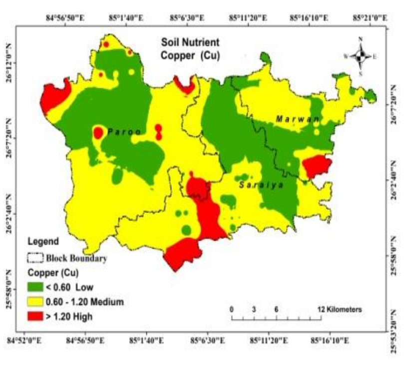

Fig. 10. Soil available Cu ppm.

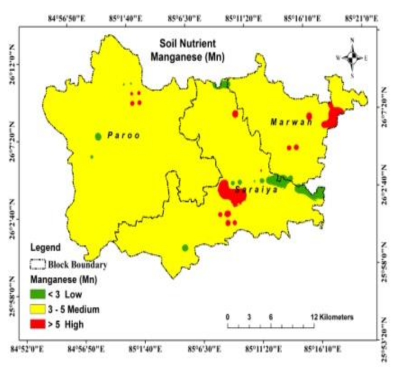

Fig. 11. Soil available Mn ppm.

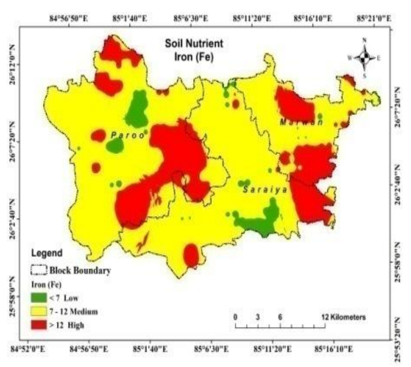

Fig. 12. Soil available Fe ppm.

CONCLUSIONS

The cluster front-line demonstration on lentil revealed a 37.28 percent increase in yield over farmers' practices. Hence, it is not the cost that deters farmers from adopting the most recent technology; ignorance is the main reason. It is moderately appropriate to describe a yield gap and an extension gap. The extension gap also influenced the deviation in crop yield due to the lack of knowledge among farmers, which was found to be 425 kg ha[1]. The average BCR (2.33) is sufficiently high to encourage farmers to adopt this advanced technology. The CFLD programme was effective in motivating farmers to adopt improved lentil cultivation practices, leading to improved relationships between farming and scientific communities.

FUTURE SCOPE

Cluster front-line demonstration technologies were also found to be cost-effective and acceptable to farming communities. It was observed that potential returns can be achieved through sharing scientific knowledge, demonstrating needs-based inputs and their appropriate application. The concept of CFLD can be applied to all categories of farmers, for a rapid and broader dissemination of best practices to other members of the agricultural community. Technological and extension gaps in lentil productivity can be bridged by popularizing improved package of practices with emphasis on improved variety, seed treatment, inclusion of micronutrients, fertilizers, weed management practices and proper insect-pest management techniques.

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Conflict of Interest. None.

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