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Research Article

EFFECT OF VARIETIES AND DIFFERENT PRECISION NUTRIENT MANAGEMENT PRACTICES ON PERFORMANCE OF BARLEY

MALI H.[1*], CHOUDHARY J.[2], SHUKLA K.B.[3] AND CHOPRA R.[4]

[1,2]Department of Agronomy, Rajasthan College of Agriculture Udaipur, 313001, Rajasthan
[3]Department of Plant Physiology, Rajasthan College of Agriculture Udaipur, 313001, Rajasthan
[4]Department of Soil Science and Agricultural Chemistry, Rajasthan College of Agriculture, Udaipur, 313001, Rajasthan
*Corresponding Author: Email-hrsaini26@gmail.com

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Abstract- Different novel approaches of nutrient managements are used to improve the performance of barley (*Hordeum vulgare* L.) under environmental constraints. The objectives of this study were to evaluate the growth, yield attributes and yield of barley. Three different barley varieties (RD 2035, RD 2552 and RD 2786)were evaluated for 2 years (2014 and 2015) with five different precision nutrient management practices using replicated trial. Precision nutrient management practices involved $PNMP_1$: RDF – half N, full P_2O_5 and K_2O as basal + remaining half N as top dressing after first irrigation; $PNMP_2$: RDF – half N, full P_2O_5 and K_2O as basal + remaining half N as top dressing before first irrigation; $PNMP_3$: 50 % of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing after first irrigation; $PNMP_4$: 70 % of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing after first irrigation; and $PNMP_5$: Soil Test Crop Response. Yield traits were measured as plant height, total tillers, ear length, grain weight, yield and harvest index. Varieties RD 2035 and 2552 recorded the highest plant heights (at 60 DAS and harvest) and number of total tillers, ear length, grain weight ear^{-1}, grain, straw and biological yield, respectively. Nutrient management practices $PNMP_5$ and $PNMP_4$ recorded highest yield and yield attributes, and can be used interchangeably.

Keywords- Varieties, Green Seeker, STCR, barley, plant height, tillers ear length and yield

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Introduction

Barley (*Hordeum vulgare* L.) is an important crop of India, which is generally grown in areas where irrigation facilities are limited, as it can tolerate moisture and salt stress to a great extent [1]. In India, barley was cultivated on 0.67 m ha area during 2013-14 with 1.83 m t of production at an average productivity status of 27.1 q ha^{-1}[2]. Yield and yield attributes are complex traits, which exhibit polygenic or quantitative inheritance pattern. The expression of quantitative traits is largely governed by environment in which they are exposed; and, thus, it results into scale or rank shift of their performance [3-5].Therefore, the identification of high yielding adaptable varieties as per crop growing situation is considered to be the first and foremost step for the development of production technology. Adequate mineral fertilization is considered to be one of the most important pre-requisite for higher yield. Amongst nutrients, nitrogen plays an important role in synthesis of chlorophyll, amino acids and other organic compounds of physiological significance for plant system [6]. Next to nitrogen, phosphorus is of paramount importance for energy transfer in living cells by mean of high energy phosphate bonds of ATP. Thus, it plays pivotal role in formation and translocation of carbohydrates, fatty acids, glyceroids and other essential intermediate compounds. Likewise, potassium act as a chemical traffic policeman, root booster, stalk strengthen, food formic, sugar and starch transport, protein builder, breathing regulator, water stretcher and as a disease retarder thus improve grain quality [7]. Existing fertilizer recommendations for barley often consist of one predetermined rate of nitrogen, phosphorus and potassium for vast areas of barely cultivation. Such recommendation assumes that the need of barley crop for nutrients is constant over time and large areas. But the needs of barley crop for supplemental nutrients can vary greatly depending on varieties used, fields, seasons and years as a result of differences in crop growing conditions, soil management, and climate. Hence, the management of nutrients for barley requires a new approach, which enables adjustments in applying N, P and K to accommodate the field specific needs of the barley crop for nutrients. The novel approach of nitrogen management is Green Seeker, which is an integrated optical sensing, and application system that measures crop status and variably applies the crop's nitrogen requirements. Another novel approach is STCR (soil test crop response) based nutrient management. Given the soil test values and target yield, one can evaluate fertilizer nutrient dose to be applied for that particular type of soil, variety and season. Using IPNS (integrated plant nutrition system) based equations, required quantity of fertilizer nutrients are to be applied. Thus, these fertilizer target yield equations that would take care of fertilizer use efficiency, soil use efficiency, farmers' available resources which is not possible with other conventional methods. Thus, it confirms that the use of IPNS recommendations will not only help in saving of fertilizers and improving the economy but also help in improvement of soil health [8]. The objectives of the present study were to 1) to evaluate growth, yield and yield attributed of barley under different precision nutrient management practices and 2) estimate the correlation among yield and yield attributes.

MaterialsandMethods

The soil of experimental site was clay loam in texture slightly alkaline in reaction,

low in available nitrogen (287.60 and 288.30 kg ha^{-1}), medium in phosphorus (18.8 and 20.5 kg ha^{-1}) and high in available potassium (338.7 and 346.4 kg ha^{-1}) status during, 2014-15 and 2015-16, respectively.

The experiment was laid out in a RBD (Factorial) with 15 treatment combinations which consisted of three varieties (RD 2035, RD 2552 and RD 2786) and five precision nutrient management levels ($PNMP_1$: RDF – half N, full P_2O_5 and K_2O as basal + remaining half N as top dressing after first irrigation, $PNMP_2$: RDF – half N, full P_2O_5 and K_2O as basal + remaining half N as top dressing before first irrigation, $PNMP_3$: 50 % of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing after first irrigation, $PNMP_4$: 70 % of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing after first irrigation, $PNMP_5$: STCR (Soil Test Crop Response) were replicated three times. * RDF= 60 kg N, 30 kg P_2O_5, 20 kg K_2O ha^{-1}. The barley varieties *viz.* RD 2035, RD 2552 and RD 2786 were sown on 19th and 22th November during 2014 and 2015 as per treatments. A uniform seed rate of 100 kg ha^{-1} was used at inter row spacing of 22.5 cm.

Fertilizer treatments were applied to different plots at basal as per treatment through urea, SSP and MOP. N top dressing was done as per treatment through urea. The Green Seeker readings were collected by holding the Green Seeker sensor approximately 0.7–0.9 m above the canopy and walking at a constant speed in all experimental plots. The sensor path was parallel to the seed rows or the beam of light was perpendicular to the seed row. The Green Seeker sensor uses built-in software to calculate NDVI directly. Green seeker based N (46 kg ha^{-1} and 41 kg N ha^{-1}) top dressed with 50 per cent and 70 per cent recommended N as basal, respectively. The fertilizer adjustment equation (STCR) for yield target of 50 q ha^{-1} in NCR of Delhi without FYM is used because the fertilizer adjustment equation for Udaipur region is not available and soil available NPK and Soil type of Udaipur are quite similar to that of NCR Delhi [8].

$$FN = 3.69T\text{-}0.64SN,\ FP_2O_5 = 2.93T\text{-}5.24SP,\ FK_2O = 2.22T\text{-}\ 0.31SK$$

Where, FN= Fertilizer N requirement (kg ha^{-1})
SN= Soil available N (kg ha^{-1})
FP_2O_5 = Fertilizer P_2O_5 requirement (kg ha^{-1})
SP = Soil available P (kg ha^{-1})
FK_2O = Fertilizer K_2O requirement (kg ha^{-1})
SK = Soil available K (kg ha^{-1})
T= yield target (q ha^{-1})

On the basis of these equation, ready reckoners on soil test based fertilizer requirement was (10:95:10 kg N, P_2O_5 and K_2O ha^{-1}) for yield target of 50 q ha^{-1} [8]. The other agronomic practices were carried out as per the package of practices of barley for this zone. The crop was harvested on 24th March 2015 and 19th March 2016, respectively. The observation for plant population was taken by manually counting of number of plants from 1 m row length from each plot. Observations for plant height were taken from five randomly selected spots in each plot at respective growth stage and their averages were used for calculation. Total tillers m^{-1} row length was manually counted at 50 per cent maturity, ear length and grains weight ear^{-1} computed from 5 randomly selected ears and their mean were used for calculation. Grain, straw and biological yield was recorded from each plot (kg $plot^{-1}$) and converted into q ha^{-1}. Harvest index was computed as dividing the grain yield by biological yield.

Results and Discussion

Effect of varieties

Growth attributes

Pooled analysis revealed that plant population m^{-1} row length at 15 DAS did not differ among varieties [Table-1]. Similarly, the plant height at 30 DAS was non-significant among all the test varieties. However, at 60 DAS and harvest plant height was recorded significantly different with highest being in variety RD 2035 (74.49 and 92.22 cm).The difference in plant height of different varieties is due to genetic characteristics of these varieties [9,10].

Yield attributes and yield

The number of tillers m^{-1} row length was significantly higher in variety RD 2552 (89.33) as compared to RD 2035 [Table-2]. This might be due to more tillering ability and higher growth of variety RD 2552[8].Varietal differences in performance of total tillers and grain weight ear^{-1} may contribute to higher LAI and efficient translocation of metabolites towards grain formation [12,13].

Results of present study revealed that, the higher grain yield (48.57 q ha^{-1}) of barley variety RD 2552 may be attributed to its higher biomass accumulation, which is due to its ability to produce high number of tillers and proper partitioning of nutrients as evident from equally higher yield attributes *i.e.* total tillers, ear length and grains weight ear^{-1} [Table-2 and 3] [14]. A significant and positive correlation was also recorded with grain yield and yield attributing *viz.* grain yield *vs.* ear length (r = 0.835**) and grain yield vs. grain weight ear^{-1} (r = 0.885**) [15] and [16]. Further, capability of barley variety RD 2552 to produce higher straw yield (70.49 q ha^{-1}) seems to be primarily due to increase in morphological parameters (tillers m^{-1} row length) and stem thickness. The biological yield is a function of grain and straw yield. Thus, significant increase in biological yield of variety RD 2552 could be ascribed to increase in grain and straw yield [17] and [16]. Harvest index was not significantly influenced by varieties.

Effect of precision nutrient management practices

Growth attributes

The pooled results of the investigation [Table-1] reflect that plant population at 15 DAS and plant height at 30 DAS was not affected by different nutrient management practices. However, plant height at 60 DAS (76.35 cm) and harvest (92.46 cm) was recorded highest in precision nutrient management through STCR ($PNMP_5$), which was significantly higher over rest of the precision nutrient management practices. In general the overall improvement in growth of barley crop with the addition of N, P_2O_5 and K_2O could be ascribed to pivotal role of these nutrients in several physiological and biochemical processes which are of vital importance for development of the plants. It is well established that nitrogen is involved in the synthesis of amino acids [18]. Under STCR based nutrient application P_2O_5 was applied 80 kg ha^{-1} which is 50 kg higher than RDF (30 kg). This increased phosphorus ascribed to increased growth [19]. It is an established fact that among nutrients, phosphorus is most important for exploiting genetic potential of crop for its growth and development [20]. In addition to its structural role in nucleic acid, nucleotide and phospholipids, phosphorus has essential regulatory functions in photosynthesis and carbohydrate metabolism in its formation of pyrophosphate bonds which allows energy transfer and is required for all biochemical process which require energy. So, it is considered as energy currency with in plant system [21,20]. An adequate supply of available phosphorus is required by plants at early growth stage because at this stage rate of metabolism and cell division is high and limited root system which is not capable of drawing sufficiently phosphorus from soil.

Yield attributes and yield

The pooled results [Table-2] indicated that STCR based nutrient management ($PNMP_5$) significantly outperformed and recorded the maximum yield attributes *viz.* number of total tillers m-1 row length (89.71), ear length (7.51 cm) and grain weight ear^{-1} (2.45 g), which was on par with application of 70 per cent of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing ($PNMP_4$). It is established fact that photosynthesis together with the availability of assimilates (source) and storage organs (sink) exert an important regulative function on complex process of yield formation. The regulatory function of phosphorus in photosynthesis and carbohydrate metabolism of leaves can be considered to be the important factor that limits plant growth particularly during reproductive phase. The level of phosphorus during this period regulates starch/sucrose ratio in the leaves and reproductive organs [22].

Results from present study indicate that nutrient management through STCR ($PNMP_5$) increased the yield attributes and yield significantly. It is because STCR is based on the soil test and required quantity of N (10 kg ha^{-1}), P_2O_5 (80 kg ha^{-1}) and K_2O (10 kg ha^{-1}) were applied to optimize the target yield of this zone. The higher quantity of phosphorus was applied through STCR as compared to conventional application, which in turn increased the root biomass, total tillers, ear

Table-1 *Effect of varieties and precision nutrient management practices on plant population and plant height of barley*

Treatments	Plant population (m^{-1} row length) at 15 DAS			Plant height (cm)								
				30 DAS			60 DAS			At harvest		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
Varieties												
RD 2035	59.13	58.13	58.63	22.56	23.65	23.10	75.49	73.49	74.49	92.94	91.49	92.22
RD 2552	61.07	59.40	60.23	22.23	23.15	22.69	72.74	71.19	71.97	88.25	87.21	87.73
RD 2786	59.33	57.80	58.57	22.09	22.85	22.47	70.04	68.09	69.06	84.50	83.15	83.82
SEm±	0.79	0.75	0.54	**0.39**	**0.31**	**0.25**	**1.26**	**1.01**	**0.81**	**1.39**	**1.36**	**0.97**
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**3.66**	**2.92**	**2.29**	**4.02**	**3.93**	**2.75**
Nutrient Management												
$PNMP_1$	58.78	57.67	58.22	21.81	23.02	22.42	67.76	70.43	69.09	86.64	85.71	86.18
$PNMP_2$	61.44	59.11	60.28	21.96	23.09	22.52	71.14	69.14	70.14	86.98	84.37	85.67
$PNMP_3$	59.22	58.00	58.61	22.04	22.93	22.48	72.42	70.42	71.42	87.42	85.57	86.50
$PNMP_4$	59.11	58.11	58.61	22.87	23.21	23.04	74.62	69.76	72.19	87.95	89.68	88.81
$PNMP_5$	60.67	59.33	60.00	22.79	23.85	23.32	77.83	74.86	76.35	93.84	91.09	92.46
SEm±	**1.02**	**0.97**	**0.70**	**0.50**	**0.40**	**0.32**	**1.63**	**1.30**	**1.04**	**1.79**	**1.75**	**1.25**
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**4.73**	**3.77**	**2.96**	**5.19**	**5.07**	**3.55**

$PNMP_1$: RDF – half N, full P_2O_5 and K_2O as basal. Remaining half N as top dressing after first irrigation.
$PNMP_2$: RDF – half N, full P_2O_5 and K_2O as basal. Remaining half N as top dressing before first irrigation.
$PNMP_3$: 50 % of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing after first irrigation.
$PNMP_4$: 70 % of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing after first irrigation.
$PNMP_5$: STCR (Soil Test Crop Response).

Table-2 *Effect of varieties and precision nutrient management practices on number of total tillers,ear length and grain weight ear^{-1} of barley*

Treatments	Total tillers (m^{-1} row)			Ear length (cm)			Grain weight ear^{-1} (g)		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
Varieties									
RD 2035	83.94	82.02	82.98	6.85	6.33	6.59	1.97	1.93	1.95
RD 2552	90.43	88.23	89.33	7.57	7.19	7.38	2.40	2.35	2.38
RD 2786	86.92	85.48	86.20	7.32	6.68	7.00	2.25	2.14	2.20
SEm±	**1.15**	**1.18**	**0.82**	**0.11**	**0.06**	**0.06**	**0.04**	**0.03**	**0.02**
CD (P=0.05)	**3.32**	**3.43**	**2.33**	**0.31**	**0.18**	**0.17**	**0.11**	**0.08**	**0.07**
Nutrient Management									
$PNMP_1$	85.39	82.32	83.85	6.91	6.28	6.59	1.97	1.94	1.96
$PNMP_2$	83.60	81.92	82.76	6.73	6.23	6.48	1.91	1.85	1.88
$PNMP_3$	87.67	84.66	86.16	7.31	6.55	6.93	2.26	2.11	2.18
$PNMP_4$	89.07	87.66	88.37	7.63	7.24	7.44	2.42	2.37	2.40
$PNMP_5$	89.77	89.66	89.71	7.65	7.37	7.51	2.47	2.43	2.45
SEm±	**1.48**	**1.53**	**1.06**	**0.14**	**0.08**	**0.08**	**0.05**	**0.04**	**0.03**
CD (P=0.05)	**4.28**	**4.42**	**3.01**	**0.40**	**0.23**	**0.23**	**0.14**	**0.11**	**0.08**

$PNMP_1$: RDF – half N, full P_2O_5 and K_2O as basal. Remaining half N as top dressing after first irrigation.
$PNMP_2$: RDF – half N, full P_2O_5 and K_2O as basal. Remaining half N as top dressing before first irrigation.
$PNMP_3$: 50 % of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing after first irrigation.
$PNMP_4$: 70 % of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing after first irrigation.
$PNMP_5$: STCR (Soil Test Crop Response).

Table-3 *Effect of varieties and precision nutrient management practices on grain, straw, bilogical yield and harvest index of barley*

Treatments	Yield (q ha^{-1})											Harvest Index (%)		
	Grain				Straw				Biological					
	2014-15	2015-16	Pooled		2014-15	2015-16	Pooled		2014-15	2015-16	Pooled		2014-15	2015-16	Pooled
Varieties															
RD 2035	44.97	42.83	43.90		67.62	61.36	64.49		112.59	104.19	108.39		39.80	40.94	40.37
RD 2552	49.43	47.71	48.57		71.99	68.99	70.49		121.42	116.69	119.06		40.69	40.90	40.80
RD 2786	46.78	45.88	46.33		70.40	64.04	67.22		117.19	109.92	113.55		39.97	41.75	40.86
SEm±	**0.64**	**0.69**	**0.47**		**1.14**	**1.09**	**0.79**		**1.25**	**1.50**	**0.98**		**0.53**	**0.42**	**0.34**
CD (P=0.05)	**1.87**	**1.99**	**1.33**		**3.30**	**3.15**	**2.23**		**3.62**	**4.35**	**2.77**		**NS**	**NS**	**NS**
Nutrient Management															
$PNMP_1$	45.38	41.77	43.58		67.78	60.72	64.25		113.17	102.49	107.83		40.19	40.71	40.45
$PNMP_2$	41.68	40.43	41.06		65.81	59.86	62.84		107.50	100.30	103.90		38.74	40.23	39.49
$PNMP_3$	45.79	45.73	45.76		69.86	64.27	67.06		115.65	110.00	112.82		39.53	41.61	40.57
$PNMP_4$	51.13	49.45	50.29		73.60	68.70	71.15		124.73	118.15	121.44		41.02	41.95	41.49
$PNMP_5$	51.31	49.97	50.64		72.98	70.44	71.71		124.29	120.41	122.35		41.28	41.48	41.38
SEm±	**0.83**	**0.89**	**0.61**		**1.47**	**1.40**	**1.02**		**1.61**	**1.94**	**1.26**		**0.69**	**0.54**	**0.44**
CD (P=0.05)	**2.41**	**2.57**	**1.72**		**4.27**	**4.06**	**2.88**		**4.68**	**5.62**	**3.57**		**NS**	**NS**	**NS**

$PNMP_1$: RDF – half N, full P_2O_5 and K_2O as basal. Remaining half N as top dressing after first irrigation.
$PNMP_2$: RDF – half N, full P_2O_5 and K_2O as basal. Remaining half N as top dressing before first irrigation.
$PNMP_3$: 50 % of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing after first irrigation.
$PNMP_4$: 70 % of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing after first irrigation.
$PNMP_5$: STCR (Soil Test Crop Response).

Table-4 *Correlation coefficient and regression equation showing relationship between independent (X) and dependent (Y) variables on the mean basis*

Dependent variables (Y)	Independent variable (X)	Correlation coefficient (r)	Regression line Y = a + bX
Grain yield (q ha^{-1})	Ear length (cm)	0.835**	Y = 1.81 + 6.36X
Grain yield (q ha^{-1})	Grain weight ear^{-1}(g)	0.885**	Y = 17.46 + 13.25X
Biological yield (q ha^{-1})	Grain yield (q ha^{-1})	0.977**	Y = 26.71 + 1.88X
Biological yield (q ha^{-1})	Straw yield (q ha^{-1})	0.975**	Y=-16.45 + 1.93X

length and grain weight ear^{-1} due to adequate supply of phosphorus to the crop. Due to high phosphorus more assimilates are transferred into the storage organ (seeds) ultimately increase the grain weight ear^{-1}. The significantly increase in grain yield (50.64 q ha^{-1}) under STCR based nutrient application (PNMP$_5$) which was at par with 70 per cent of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing (PNMP$_4$)this could be ascribed to the fact that yield of crop is resultant of several yield attributing characteristics which are interrelated [19]. While, improvement in straw and biological yield appears to be on account of significantly improvement in biomass accumulation by components at each stage and various plant parts at harvest of the crop. Significant positive correlation of biological yield with grain yield (r = 0.977**), straw yield (0.975**) was recorded. The application of 70 per cent of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing (PNMP$_4$), provided the nitrogen to the crop for longer period and in greater amount at the time of sowing and remaining N to the standing crop according to the actual need of crop which facilitate in improvement in plant growth, vigour and production of sufficient photosynthates through increased leaf area by higher tillering. [23]also reported stimulation of tillering with optimal application of N might be due to its positive effect on cytokinin synthesis. A faster growth rate in terms of increased dry matter production with the precise application of nitrogen might have played a significant role in production of higher number of tillers and their development through reduction in competition for photo synthates with mother shoots and thus helped in survival till harvest. The combined effect of optimum amount of fertilizer at right time has significant effect on ear length [24]. [25] reported higher spike length by application of N fertilizer at one month later of sowing. Under the present investigation, profound effect of nitrogen on crop growth and subsequently on yield attributes and yield seems to be due to maintenance of congenial nutritional environment in barley plants on account of their greater availability from soil at the time of greatest demand. Further, the correlation analysis also substantiated strong dependence of grain yield on yield attributes *viz*. ear length (r = 0.835**) and grain weight ear^{-1} (r = 0.885**).

The significant increase in straw and biological yield due to application of 70 per cent of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing (PNMP$_4$) appears to be due to its direct influence on dry matter production at successive stages and increased photosynthetic efficiency and nutrient uptake. While, indirect influences seem to be due to increase in total tillers, ear length and grain weight ear^{-1} [Table-2 and 3]. These results are in agreement with [26] and [27] who have documented significant positive influence of nitrogen application on yield attributes and yield of cereals. Different precision nutrient management practices had no significant effect on harvest index of barley.

Conclusion

From present investigation, it can be concluded that variety RD 2552 performed better as compared to RD 2035 and RD 2786. Nutrient management through STCR (PNMP$_5$) and PNMP$_4$ were recorded significantly higher plant height, yield attributes and yield as compared to other nutrient management practices. Nutrient management practices PNMP$_5$and PNMP$_4$ can be interchangeably used.

Conflict of Interest: None declared

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