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Cientific Paper

Yield and physicochemical characteristics of grapes from vines treated with extract of *Ecklonia maxima*

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Abstract

This trial aimed to evaluate the effects of *Ecklonia maxima* extract (Kelpak®) on yield and physicochemical characteristics of the clusters from wine grapevines. The treatments consisted of different doses of the commercial product Kelpak®, concentrate prepared of seaweed *Ecklonia maxima*, rich in natural auxins, as follow: T1 – Water, T2 – Extract of *Ecklonia maxima* – 2.5 L ha^{-1}, T3 – Extract of *Ecklonia maxima* – 3.75 L ha^{-1}, applied with a hand sprayer with a volume about 170 mL per plant, equivalent to 900 L ha^{-1}. The following variables were evaluated: weight of clusters, number of clusters per plant, number of berries per cluster, weight of berries, width and length of the clusters, soluble solids content, pH and trititable acidity. The physiological disorders in clusters were visually evaluated as follow: cracking, dehydration, shot berries and cluster compactness. For the grapevines cv. Merlot, the application of Kelpak at 2.5 L ha^{-1} increased the length of clusters and decreased the occurrence of shot berries, compared to the treatment with 3.5 L ha^{-1}, but without differences in relation to the control with water. For the cv. Cabernet Sauvignon there was an increase in cluster compactness and reduction of berries dehydration for the incidence between 0-5% of the berries for the treatment with 2.5 L ha^{-1} of *Ecklonia maxima* extract, differing from the control. Considering the results, the use of *Ecklonia maxima* has a potential to increase grapes quality, and new researches should be carried out to improve its performance in commercial vineyards.

Key words: auxins, physiological disorders, seaweed extracts.

Resumo

Rendimento e características físico-químicas das uvas de vinhas tratadas com extrato de *Ecklonia maxima*

O objetivo deste estudo foi avaliar os efeitos do extrato de *Ecklonia maxima* (Kelpak®) sobre o rendimento e as características físico-químicas dos cachos das videiras viníferas. Os tratamentos consistiram de diferentes doses do produto comercial Kelpak®, concentrado de algas *Ecklonia maxima*, com a presença de auxinas naturais em sua composição: T1 - Água, T2 - Extrato de *Ecklonia maxima* – 2.5 L ha^{-1}, T3 - Extrato de *Ecklonia maxima* – 3.75 L ha^{-1}, aplicado com pulverizador manual com volume de aproximadamente 170 mL por planta, equivalente a 900 L ha^{-1}. Foram avaliadas as seguintes variáveis: peso dos cachos, número de cachos por planta, número de bagas por cacho, peso das bagas, largura e comprimento dos cachos, teor de sólidos solúveis, pH e acidez total titulável. Os seguintes distúrbios fisiológicos em cachos foram avaliados visualmente: rachadura, desidratação, compactação e desavinho. Para a cultivar Merlot verificou-se aumento do comprimento de cacho e a diminuição da ocorrência de desavinho com o tratamento 2.5 L ha^{-1} de *Ecklonia*

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maxima em comparação com o tratamento com 3.5 L ha^{-1}, mas sem diferenças em relação ao controle com água. Para a cv. Cabernet Sauvignon houve um aumento na compactação dos cachos e redução da incidência de desidratação das bagas entre 0-5% para o tratamento com 2.5 L ha^{-1} de extrato de *Ecklonia maxima*, diferindo-se da testemunha. Considerando os resultados, o uso de extrato de *Ecklonia maxima* tem um potencial para melhorar a qualidade de uvas e, novas pesquisas deveriam ser conduzidas para melhorar a sua eficiência em vinhedos comerciais.

Palavras-chave: auxinas, distúrbios fisiológicos, extratos de algas marinhas.

Resumen

Rendimiento y características físico-químicas de las uvas de vides tratadas con extracto de *Ecklonia maxima*

El objetivo de este estudio fue evaluar los efectos del extracto de *Ecklonia maxima* (Kelpak®) sobre el rendimiento y las características físico-químicas de los racimos de las vides vinícolas. Los tratamientos consistieron de diferentes dosis del concentrado de algas *Ecklonia maxima*, con la presencia de auxinas naturales en su composición: T1 - Agua, T2 - Extracto de *Ecklonia maxima* - 2.5 L ha^{-1}, T3 - Extracto de Ecklonia - 3,75 L ha^{-1}, aplicado con pulverizador manual con un volumen de aproximadamente 170 mL por planta, equivalente a 900 L ha^{-1}. Se evaluaron las siguientes variables: peso de los racimos, número de racimos por planta, número de bayas por racimo, peso de las bayas, ancho y longitud de los racimos, contenido de sólidos solubles, pH y acidez total titulable. Los siguientes trastornos fisiológicos en racimos fueron evaluados visualmente: agrietamiento, deshidratación, compactación y desavino. Para la cultivación de Merlot se verificó un aumento de la longitud de racimo y disminución de la ocurrencia de desavino con el tratamiento 2.5 L ha^{-1} de *Ecklonia maxima* en comparación con el tratamiento con 3.5 L ha^{-1}, pero sin diferencias en relación al control con agua. Para la cv. Cabernet Sauvignon tuvo un aumento en la compactación de los racimos y reducción de la incidencia de deshidratación de las bayas entre el 0-5% para el tratamiento con 2.5 L ha^{-1} de extracto de *Ecklonia maxima*, diferenciándose del testigo. Considerando los resultados, el uso de extracto de *Ecklonia maxima* tiene un potencial para mejorar la calidad de las uvas y nuevas investigaciones deberían ser conducidas para mejorar su eficiencia en viñedos comerciales.

Palabras clave: auxinas, trastornos fisiológicos, extractos de algas marinas.

Introduction

The physiological disorder in grapes known as "*coulure*" or "poor set" is the result of metabolic reactions due to climatic conditions that causes failures in berries development after anthesis. This problem is triggered by periods of cool, cloudy and rainy weather or very high temperatures. This also can happen in grapevines that has little sugar in the tissue. In such conditions, the flowers remain closed and are not fertilized. Therefore, the flowers are not pollinated, avoiding the berries development and abortion (ROBINSON, 2006).

The "*Coulure*" also causes the formation of irregular clusters, less compact than normal. These clusters are more susceptible to the occurrence of fungal diseases. The yield is also reduced. The grapevine cultivars more susceptible to "*Coulure*" are Grenache, Malbec, Merlot and Moscatel Ottonel. Other possible causes of the "*Coulure*" could be related to the conditions and/or plant management of the vineyard, such as: late or too heavy pruning, fertile soils, excessive fertilizing, inadequate rootstock or scion selection (ROBINSON, 2006).

This disorder is related to other known as "*Millerandage*" or "shot berries" where the berries from the same cluster varies very much in size and maturation, imparing the quality and yield, caused by problems related to abnormal fecundation. The nutritional shortage is also related to the "*Millerandage*", specially regarded to the elements zinc and bore (PIRES and POMMER, 2003). There are also reports that established relationships between lack of pollination and fruit set to inadequate levels of auxins.

The auxins has an important role in pollinic tube growth, in this way the boron is an inhibitor of the synthesis of IAA-oxidase that breaks the auxin, and both present a preponderant function in fructification. The presence of great amounts of auxins in fruits is the main inhibitory factor of fruit abscission, which normally happens when the auxins content in fruits decreases (LUCKWILL, 1953).

The bioregulators are composts that promote physiological responses in plants in very low concentrations, being natural substances and with analogous effects of plant hormones. In this category are included plant extracts, seaweed extracts and microbial secretions. Between the seaweed species, some of them are being explored for this finality, such as: *Ascophyllum nodosum, Ecklonia maxima, Macrocystis pyrifera e Durvillea potatorum*.

The specie *Ecklonia maxima*, also known as seaweed bamboo, is found in the coast of the South Africa, and its extract has been used in agriculture as biostimulant, considering their compounds such as nutrients and plant hormones, specially, citokins and auxins (STIRK et al., 2004); and also polyamins putrescin and spermin (PAPENFUS et al., 2013). Its main effect is auxinic, it is a substance allowed in organic systems. Between the main auxins found, it could be cited: indole-3-acetic acid, indol3-3-piruvic, acetilglicine-3-indole, indole-propionic, indole-latic acid (CROUCH et al., 1992).

This auxinic effect was verified by Crouch and Van Staden (1991) in a trial of rooting of mung beans, where they verified the presence of rooting promoter in concentrate prepared of seaweed from the specie *Ecklonia maxima* (Osbeck). The maximum response was found with a 10% solution. This concentration also promoted the rooting of six ornamental species.

The effects of leaf applications of a commercial formulation of seaweed concentrate of *Ecklonia maxima* on plant growth of sugarbeat were evaluated by Featonby-Smith and Van Staden (1983). The concentration of 0.2% increased the growth of the plants, independently of the use of chemical fertilizers in soil. Additionally, the levels of cytokinin effect in plants were inversely related to growth.

In a trial carried out in green house, with tomato plants, Featonby-Smith and Van Staden (1983) verified that the extract of seaweed Ecklonia maxima at 2%, increased the plant growth by regular spraying or dipping the plants in the solution. Independently of the application way, the authors found increases in roots growth and reduction of gall nematodes.

In this context, this trial aimed to evaluate the effects of *Ecklonia maxima* extract (Kelpak®) on yield and physicochemical characteristics of the clusters from wine grapevines.

Material and methods

This trial was carried out in an experimental vineyard trained in a Combi System (California "U" trellis x Double Curtain), spaced 3.5 x 0.5 m, with three grapevine cultivars: Merlot, Cabernet Sauvignon and Sangiovese, planted in 2003 with rootstocks 110R and SO4 (Fig. 1). The vineyard was located in Faenza-RA, Emilia-Romagna Region, Northern of Italy.

The treatments consisted of different doses of the commercial product Kelpak®, concentrate prepared of seaweed *Ecklonia maxima*, rich in natural auxins, as follow: T1 – Water, T2 – Extract of *Ecklonia maxima* – 2.5 L ha^{-1}, T3 – Extract of *Ecklonia maxima* – 3.75 L ha^{-1}.

The treatments were applied with a hand sprayer with a volume about 170 mL per plant, equivalent to 900 L ha^{-1}. The treatments were performed twice, the first time when the vines reached the phonological stage of 6-8 leaves and pre-flowering (13/05/2013 – cvs Merlot and Sangiovese; 21/05/2013 – cv Cabernet Sauvignon) and the second spraying at the beginning of anthesis (27/05/13 – cvs Merlot e Sangiovese; 31/05/2013 – cv Cabernet Sauvignon).

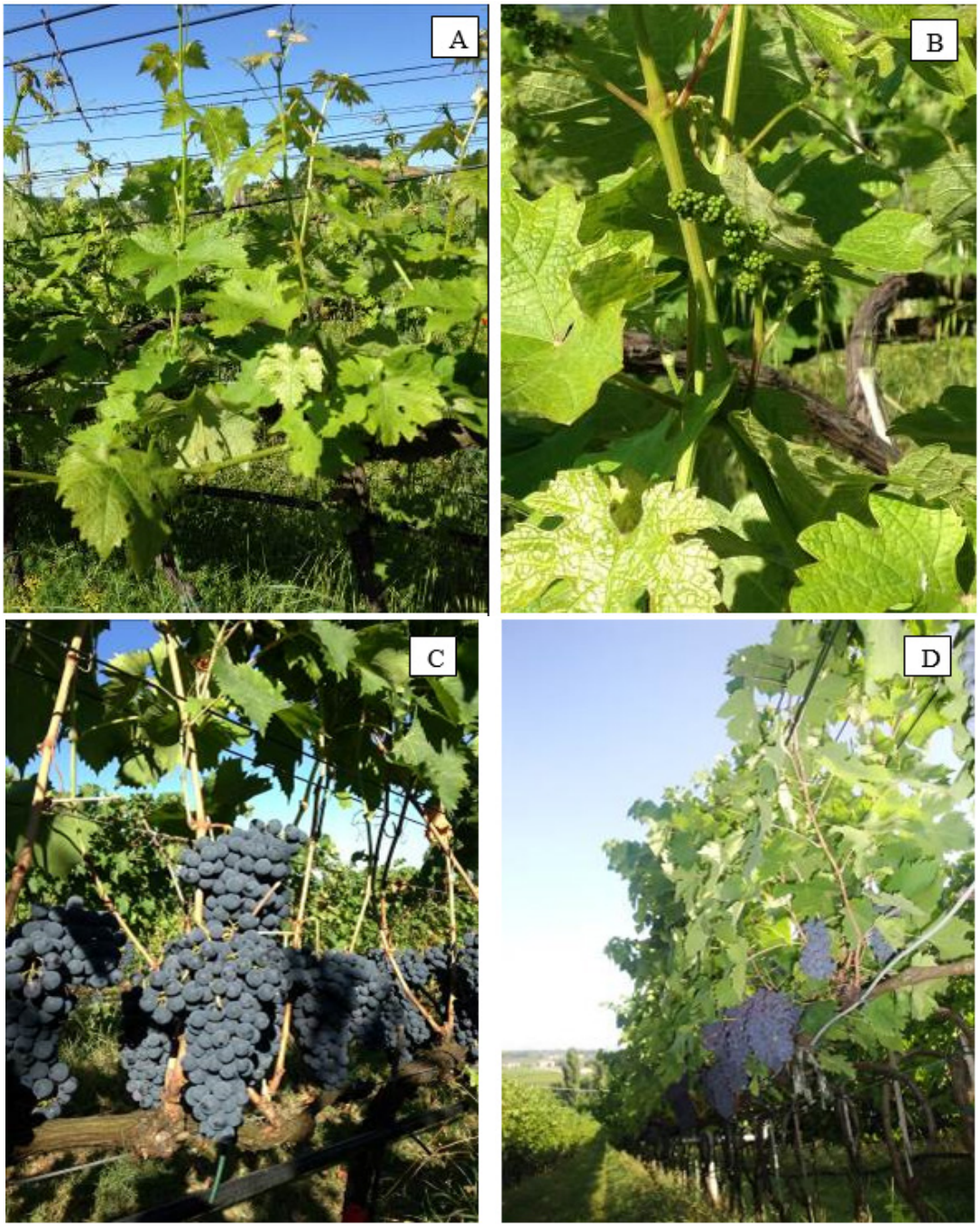

Figure 1. Experimental area for the trial with the use of extract of *Ecklonia maxima* in a vineyard trained in a Combi system at the first application with 6-8 leaves (A e B) and close to the harverst (C e D) (Faenza-RA, Italy).

The following variables were evaluated: weight of clusters, number of clusters per plant, number of berries per cluster (10 clusters per plot), weight of berries (100 berries per plot), width and length of the clusters, soluble solids content, pH and trititable acidity. The physiological disorders in clusters were visually evaluated as follow: cracking, dehydration, shot berries (grade: 0%, 0-5%, 5-25%, 25-50% and >50%) and cluster compactness (1= very loose, 9 = very compact (OIV, 2012).

The experimental design for each cultivar was in randomized blocks, with five replications and experimental plots constituted by three plants. All data was submitted to analysis of variance and Student Newman-Keuls multiple comparison test ($p \leq 0.05$), using the statistical package Sisvar 5.0 (FERREIRA, 2011).

Results and Discussion

For the grapevines cv. Merlot, it was verified that the treatment with 2.5 L ha^{-1} of *Ecklonia maxima* extract increased the length of clusters and decreased the occurrence of shot berries between 0-5% of the berries from each cluster, compared to the treatment with 3.5 L ha^{-1}, but without differences in relation to the control with water (Table 1). Several authors reported that the use of plant regulators promotes the increase the weight, length and width of clusters, rachis and berries of grapes (TECCHIO et al., 2006; MACEDO et al., 2010; MOREIRA et al., 2010; GUERIOS et al., 2014).

For the other variables evaluated, it was not verified meaningful differences and the yield ranged between 19.6 and 23.6 t ha^{-1}. Differently, Norrie and Keathley (2006) verified that the use of seaweed *Ascophyllum nodosum* extract, increased the yield in 60.4%, and the cluster weight in 39% of grapevines cv. Thompson Seedless (*Vitis vinifera* L.).

Zodape et al. (2011) also reported increase of 60.9% of yield in tomato plants by the use of 5% extract of seaweed *Kappaphycus alvarezii* with increase in number and weight of fruits.

Table 1. Physicochemical characteristics of grapes and yield of grapevines cv. Merlot treated with different doses of *Ecklonia maxima* extract (Faenza-RA, Italy).

Treatments	Soluble solids	Trititable acidity (g L^{-1})	pH	Number of berries	Cluster weight (g)	Berry weight (g)
Control	21.0	6.59	3.428	113.0	210.0	2.05
2.5 L ha^{-1}	21.4	6.64	2.456	119.8	212.0	1.95
3.75 L ha^{-1}	21.9	6.89	3.484	99.6	183.5	2.08
C.V. (%)	4.7	8.9	1.3	15.9	22.0	10.2
Treatments	Cluster length (cm)	Cluster width (cm)	Number of clusters	Yield (kg ha^{-1})	Compactness	
Control	15.8 ab	10.4	17.6	23,262.6	3.8	
2.5 L ha^{-1}	17.4 a	10.2	19.1	23,602.6	3.8	
3.75 L ha^{-1}	14.5 b	9.6	19.2	19,598.3	3.8	
C.V. (%)	8.9	9.4	14.8	22.5	17.3	
Treatments	Dehydration			Shot berries		
	0%	0-5%	5-25%	0%	0-5%	5-25%
Control	84	16	0	8	68 ab	24
2.5 L ha^{-1}	44	40	16	20	56 b	24
3.75 L ha^{-1}	76	20	4	8	84 a	8
C.V. (%)	34.2	103.9	279.3	145.9	17.9	91.8

Means followed by the same letter do not differ by the Student Newman-Keuls test, p ≤ 0,05.

For the cv. Cabernet Sauvignon there was an increase in cluster compactness and reduction of berries dehydration for the incidence between 0-5% of the berries for the treatment with 2.5 L ha^{-1} of *Ecklonia maxima* extract, differing from the control (Table 2).

For the other variables, it was not notice differences between the treatments, nevertheless there was a tendency of increment in weight and number of berries for the treatments with *Ecklonia maxima* extract, what could explain the higher compactness of cluster and lower incidence of dehydration. In general, the yield was high, ranging between 19.8 and 23.2 t ha^{-1}.

Table 2. Physicochemical characteristics of grapes and yield of grapevines cv. Cabernet Sauvignon treated with different doses of *Ecklonia maxima* extract (Faenza-RA, Italy).

Treatments	Soluble solids	Trititable acidity (g L^{-1})	pH	Number of berries	Cluster weight (g)	Berry weight (g)
Control	20.5	7.57	3.282	131.1	200.8	1.66
2.5 L ha^{-1}	18.9	8.96	3.210	138.1	226.4	1.70
3.75 L ha^{-1}	20.7	7.79	3.272	134.8	219.9	1.75
C.V. (%)	4.9	9.6	3.02	14.5	19.7	9.3
Treatments	Cluster length (cm)	Cluster width (cm)	Number of clusters	Yield (kg ha^{-1})	Compactness	
Control	15.2	9.0	17.3	19,853.5	5.1 b	
2.5 L ha^{-1}	15.5	9.3	17.9	23,171.3	7.6 a	
3.75 L ha^{-1}	15.1	9.8	16.7	21,275.0	6.2 ab	
C.V. (%)	7.2	13.2	13.2	22.3		
Treatments	Dehydration			Shot berries		
	0%	0-5%	5-25%	0%	0-5%	5-25%
Control	40 ab	48 ab	8	68	32	0
2.5 L ha^{-1}	76 a	20 b	5	60	40	0
3.75 L ha^{-1}	24 b	76 a	0	48	52	0
C.V. (%)	54.5	53.2	223.6	47.4	67.3	-

Means followed by the same letter do not differ by the Student Newman-Keuls test, $p \leq 0,05$.

For the cv. Sangiovese no meaningful differences were verified between the treatments for the variables investigated, although there was tendency of increase in berry weight for the treatments with E. maxima extract, as well the decrease in berries dehydration for the treatment with 2.5 L ha^{-1} of E. maxima extract (table 3). In general, the yield was very high, ranging between 23.4 and 27.9 t ha^{-1}, and soluble solids content between 18.5 and 22.1%.

Considering all the trials, the most remarkable results from the use of Kelpak® (E. maxima) was verified for the dose of 2.5 L ha^{-1}, with different results for each cultivar. In 'Merlot' grapevines, the most important effect was concerned to the reduction of shot berries in the level of severity of 0-5%, in order of 17.6% in relation to control, although the higher dose (3.75 L ha^{-1}), caused an increase in this disorder (table 1). The specie E. maxima, also known as seaweed bamboo, presents in its composition natural auxins (STIRK et al., 2004), synthesized by the metabolic pathway of tryptophan or indole (TARAKHOVSKAYA et al., 2007). The main auxins are the following: indole-3-acetic acid, indole-3-3-piruvic, acetilglicine-3-indole, indole-propionic, indole-lactic acid (CROUCH et al., 1992). The concentrations of the different auxins vary according to the seaweed specie (CHOJNACKA et al., 2012). According to Luckwill (1953), the auxins has an important role in pollinic tube growth, in this way the boron is an inhibitor of the synthesis of IAA-oxidase that breaks the auxin, and both present a preponderant function in fruit set and developtment.

For the other two grapevine cultivars, Cabernet Sauvignon and Sangiovese, the effects of Kelpak® treatments at 2.5 L ha^{-1} were noticed in the increase of cluster compactness and the reduction in berries dehydration (28-55%), besides of a tendency in increment of berries weight (tables 2 and 3).

Table 3. Physicochemical characteristics of grapes and yield of grapevines cv. Sangiovese treated with different doses of *Ecklonia maxima* extract (Faenza-RA, Italy).

Treatments	Soluble solids	Trititable acidity (g L^{-1})	pH	Number of berries	Cluster weight (g)	Berry weight (g)
Control	22.1	7.05	3.216	158.7	402.5	2.44
2.5 L ha^{-1}	20.5	7.27	3.132	150.8	379.6	2.53
3.75 L ha^{-1}	22.1	7.01	3.196	137.0	346.0	2.52
C.V. (%)	4.6	3.4	2.4	10.8	11,6	5.6

Treatments	Cluster length (cm)	Cluster width (cm)	Number of clusters	Yield (kg ha^{-1})	Compactness
Control	16.1	10.3	12.0	27,947.4	7.4
2.5 L ha^{-1}	16.0	10.4	11.7	25,070.6	7.4
3.75 L ha^{-1}	15.4	9.5	11.7	23,412.1	7.9
C.V. (%)	4.1	9.4	20.9	23.9	8.2

Treatments	Dehydration			Shot berries		
	0%	0-5%	5-25%	0%	0-5%	5-25%
Control	72	24	4	92	8	0
2.5 L ha^{-1}	80	20	0	84	16	0
3.75 L ha^{-1}	56	44	0	92	8	0
C.V. (%)	24.0	55.0	387.3	17.3	145.2	-

Means followed by the same letter do not differ by the Student Newman-Keuls test, $p \leq 0,05$.

No changes were verified in chemical characteristics of grape for any of the cultivars, similar to the results of Camili et al. (2013) with the use of plant regulators in 'Superior Seedless' grapevines.

Once the auxins could play an important role in inflorescence primordia differentiation, and consequently in bud fruitfulness (CONSTANTINE et al., 2007), this effect should be also investigated in future researches.

Conclusion

The positive effects of Kelpak treatments at 2.5 L ha^{-1} in physical characteristics of grapes in a one-year trial, including reduction in shot berries and dehydration and increases in cluster compactness and berry weight, indicates its potential, considering important advantages mostly for tablegrapes. New researches should be conducted in different climatic conditions, grapevine cultivars and for more cycles to improve its technology of application and elucidation of its mechanism of action.

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