THE EFFECT OF AQUASORB ON SOME SOIL PHYSICAL PROPERTIES UNDER PEDOCLIMATICAL CONDITIONS OF THE MOLDAVIAN PLAIN

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Abstract

Several series of tests were carried out to study the influence of a hydrogel (Aquasorb) on some soil physical properties (bulk density, total porosity, and moisture and water soil reserve) for maize and soybean crops. Aquasorb operates in absorption-desorption cycles of water and nutrients and has efficiency in soil up to five years. The experiment is a bifactorial one, AxB type, being placed in randomized multilevel blocks method, with three replications. The aimed factors of the experiment were the crop and the hydrogel dose. There were three variants: V_1 (control) untreated, variant V_2 - were administered doses of 15 kg ha^{-1} of Aquasorb and variant V_3 - were applied 30 kg ha^{-1}. The hydrogel was administered in the spring, before seedbed preparation at 15 cm depth, being incorporated with a disk harrow. The results showed that there was a direct interaction between the dose of hydrogel and the analysed parameters, the differences being statistically significant. The evaluation of the results was done according to the official methodology of pedological studies proposed by ICPA (Research Institute for Soil Science and Agrochemistry, Bucharest). For the bulk density, the values have outlined that for the control variant (V_1) the soil may be framed as "weak loose" (BD between 1.19-1.31 g cm^{-3}) and the treated variants can be considered as "poorly compacted" (BD between 1.32 to 1.45 g cm^{-3}). The hydrogel administration improved the soil moisture, the values ranging between 0.6% and 1% for the maize crop and between 0.8 and 1% for soybean.

Key words: hydrogel, Aquasorb, physical indicators, maize, soybean.

In Romania, the agricultural yields periodically are affected around 30-50% depending on the magnitude of extreme weather phenomena. Thereby, 64% of the agricultural area is significantly influenced by long period of drought, which decreases the agricultural sector efficiency (Hurduzeu G. *et al*, 2014, Mateescu E., Alexandru D., 2010, Galeş D.C. *et al*, 2016). In Romania and abroad, the research towards the agricultural tillage systems have been orientated in the direction of finding ways to lead to the soil structure improvement, to reduce the soil compaction and to improve the hydrological and air regime (Răus L. *et al*, 2016). Another problem detected in the NE Region of Romania is the uneven distribution of the rainfall during the growing stages which determines agro-technical issues such as water retention in the soil. One of the modern solutions to such hindrance may be the use of some hydrogels such as Aquasorb. This is a copolymer of acrylamide and potassium acrylate that has the ability to function in absorption-desorption cycles of water and nutrients and to release them progressively to the plants according to their requirements. This has effectiveness in soil up to five years which determines lower costs with irrigation (Agaba H *et al*, 2011) and a better utilisation of water in agriculture. Aquasorb proved its effectiveness especially in arid and semi-arid areas, increasing the water retention capacity in the soil and decreasing the cumulative infiltration and evaporation rate (Hayat R. Ali, S., 2004). Yang-Ren et al, 2007 showed that the hydrogel's efficiency varies with soil structure, the salts and fertilizers concentration as well as the plant breed. Hydrogels application may stabilize the soil structure, increase the erosion resistance and the infiltration rate and may decrease the surface drain (Sojka R.E. *et al*, 2007, Jihoon Kang *et al*, 2015, Sepaskhah A.R., Shahabizad V., 2010, Assaf Inbar *et al*, 2015).

MATERIAL AND METHOD

There was organized a bifactorial experiment, AxB type, using the randomized blocks method, with three replicates. The experimental factors were represented by crop and Aquasorb dose. The crops used in experiment were maize and soybean. The Aquasorb dose was applied in 3 variants: V_1 - untreated variant considered as control, V_2 - variant treated with 15 kg ha^{-1} of Aquasorb and V_3 - variant treated with 30

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kg ha-1 of hydrogel. The Aquasorb was administered in spring, prior seedbed preparation by incorporating it with a disk harrow at 15 cm depth.

The experiment was set to the Ezareni Farm within the "Ion Ionescu de la Brad" University of Agricultural Sciences and Veterinary Medicine" Iaşi (47°5' - 47°10' N latitude, 27°28' - 27°33' E longitude). The pedoclimatic conditions were specific for the Moldavian Plateau (Romania). The field had a slope of 3-4%, being a clay-loamy cambic chernozem, formed on loess deposits, with a medium to good fertility (medium content of N and P_2O and good content of K_2O), with a low acid pH and a humus content of 2.5-3.0% *(table 1).*

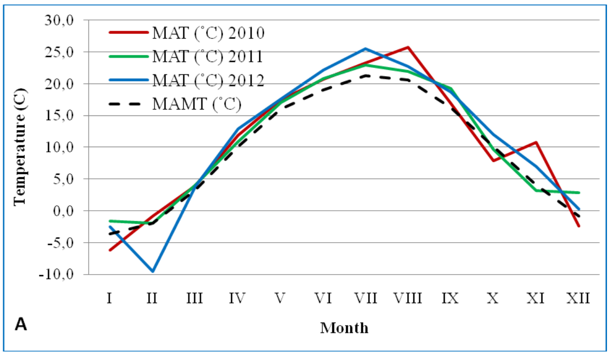
Table 1

Chemical properties of cambic chernozem from Ezareni Farm
(0-40 cm soil profile)

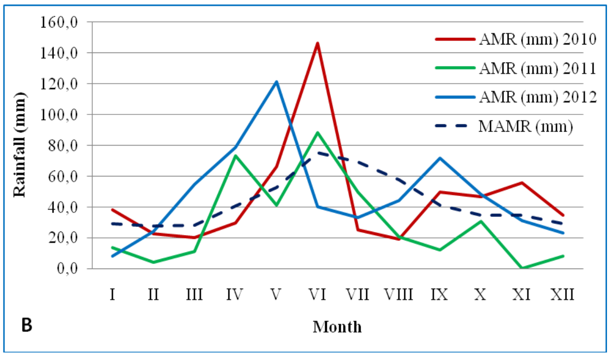
Crop	Depth (cm)	pH	Humus %	Total N %	P AL mg/kg	K AL mg/kg
Maize	0-10	6.32	2.88	0.11	34.00	174.0
	10-20	6.40	2.88	0.10	23.00	171.0
	20-30	6.51	2.76	0.09	19.00	166.0
	30-40	6.51	1.50	0.07	6.00	149.0
Average 0-40 cm		**6,44**	**2.51**	**0.09**	**20.50**	**165.0**
Soybean	0-10	6.27	3.54	0.10	27.00	195.0
	10-20	6.29	2.94	0.11	27.00	192.0
	20-30	6.40	3.18	0.10	18.00	167.0
	30-40	6.72	2.70	0.08	8.00	155.0
Average 0-40 cm		**6,42**	**3.09**	**0.10**	**20.00**	**177.3**

The climatic conditions of the experiment were characterised by an average multiannual temperature of 9.6°C and an average multiannual rainfall of 517.8 mm.

The climatic conditions during the experimentation are presented in *figure 1* (A- temperature, B- rainfall).



MAT - Multi-annual temperature
MAMT - Multi-annual mean temperature



AMR - Average monthly rainfall
MAMR - Multi-annual average rainfall

Figure 1 **Climatic factors characterisation for 2010-2012 *(A – air temperature, B – rainfall)***

The used technologies were accordingly with the crop type, respectively maize and soybean (Muntean L.S. *et al*, 2003).

In order to determine the main physical characteristics, there were collected undisturbed soil-cores in 100 cm^3 metallic cylinders using an Eijkelkamp kit *(figure 2).*

Figure 2 **Eijkelkamp kit**

The soil samples were taken from each variant, at 0-10 cm, 10-20 cm and 20-30 cm depth.

The main hydro-physical soil indexes were determined using the classical analysis methods (Rusu T., et al 2007, Canarache A., 1990).

The bulk density (BD) was determined by dividing the weight *(W)* of the soil dried in the oven to the total volume (V_t) of the sample (1).

$$BD = \frac{W}{Vt} \quad (1)$$

The total porosity (TP) was determined using the formula (2):

$$TP = \left(1 - \frac{BD}{D}\right) \times 100 \quad (2)$$

where, *TP* – total porosity of the soil volume, in %; *BD* – bulk density, in g cm^{-3}; *D* – density, in g cm^{-3} (for most of the soils the values ranged between 2.65- 2.68 g cm^{-3} for the ploughed layer and 2.70- 2.72 g cm^{-3} for the one beneath the ploughed layer).

In order to determine the *soil moisture (U,%)* soil samples were collected from different layers: 0-5 cm, 5-10 cm, 10-15 cm, 15-20 cm, 20-25 cm and 25-30 cm, in aluminum vials, which were dried in the oven. The soil moisture was calculated by dividing the evaporated water at the soil sample weight (3):

$$U\% = \frac{W_w x100}{W_{ds}} \quad (3)$$

where, *U%* - soil moisture (%); W_w – evaporated water from the sample (g); W_{ds} – dried soil weight (g).

The water reserve was calculated as water layer, in mm (4), *(Dumitru Elisabeta Dumitru, et al 2009):*

$$L_{wr} = W_g \times BD \times h \times 0.1 \quad (4)$$

where, L_{wr} – water reserve as water layer (mm); W_g – gravimetric moisture (g); *BD* – bulk density (g cm^{-3}); *h* – the thickness of the considered soil layer (cm); 0.1 – coefficient resulted from transformation of m^3 x ha^{-1} in mm.

RESULTS AND DISSCUSSION

Bulk density (BD)

The values of the bulk density presented in table 2 are average values calculated for depth (0-30 cm) and main vegetation stages (sowing, during vegetation and harvest). The statistical analysis of the average values of the bulk density highlighted significant differences between the treated variants and the control, for both crops *(table 2A).*

Table 2

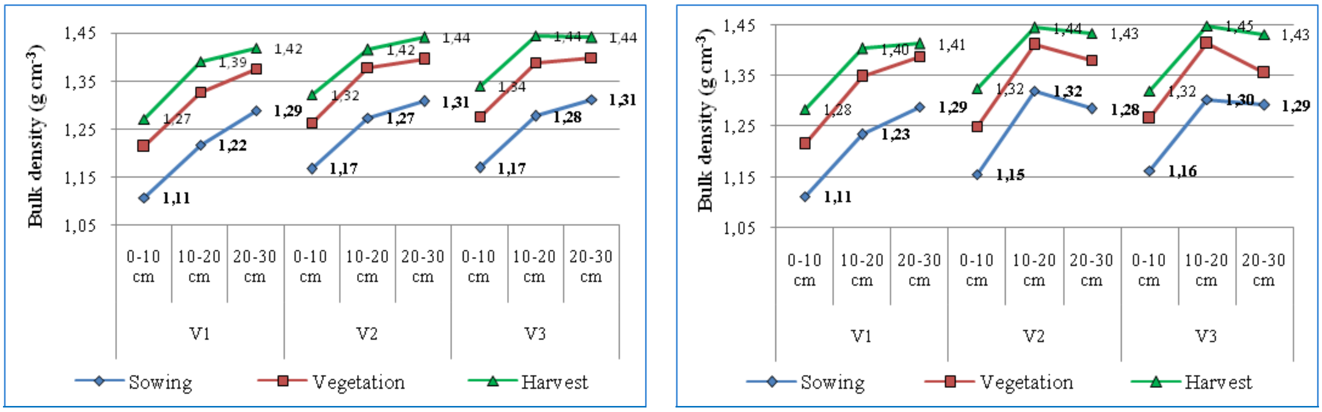
The influence of Aquasorb on some soil hydro-physical characteristics for maize and soybean crops
(Average values for years, variants, depth (0-30 cm) and growing stages)

Type of determination	Variant	Maize				Soybean			
		UM	Compared to control		Significance	UM	Compared to control		Significance
			%	Differences (UM)			%	Differences (UM)	
A. Bulk density (g cm^{-3})	V_1	1.29±0.00	100.00	0.00	Control	1.30±0.00	100.00	0.00	Control
	V_2	1.33±0.02	103.10	0.04	xx	1.33±0.01	102.31	0.03	xx
	V_3	1.34±0.01	103.88	0.05	xxx	1.33±0.00	102.31	0.03	xx
		LSD 5% = 0.013 g cm^{-3}; LSD 1% = 0.022 g cm^{-3}; LSD 0.1% = 0.041 g cm^{-3};				LSD 5% = 0.012 g cm^{-3}; LSD 1% = 0.022 g cm^{-3}; LSD 0.1% = 0.037 g cm^{-3};			
B. Total porosity (% v/v)	V_1	51.61±0.18	100.00	0.00	Control	51.30±0.15	100.00	0.00	Control
	V_2	50.13±0.79	97.14	-1.48	ooo	49.97±0.43	97.41	-1.33	ooo
	V_3	49.78±0.46	96.45	-1.83	ooo	49.89±0.31	97.25	-1.41	ooo
		LSD 5% = 0.3 % v/v; LSD 1% = 0.5 % v/v; LSD 0.1% = 1.0 % v/v;				LSD 5% = 0.3 % v/v; LSD 1% = 0.5 % v/v; LSD 0.1% = 1.0 % v/v;			
C. Soil moisture (%)	V_1	15.8±0.26	100.0	0.0	Control	15.8±0.21	100.0	0.0	Control
	V_2	16.4±0.11	103.8	0.6	x	16.6±0.12	105.1	0.8	xx
	V_3	16.8±0.07	106.3	1.0	xx	16.8±0.04	106.3	1.0	xxx
		LSD 5% = 0.4 %; LSD 1% = 0.7 %; LSD 0.1% = 1.3 %;				LSD 5% = 0.3 %; LSD 1% = 0.5 %; LSD 0.1% = 0.9 %;			
D. Water content (mm)	V_1	61.4±5.78	100.0	0.0	Control	61.7±6.14	100.0	0.0	Control
	V_2	65.7±5.15	107.0	4.3	xxx	66.4±5.87	107.6	4.7	xxx
	V_3	67.7±6.61	110.3	6.3	xxx	67.1±6.30	108.8	5.4	xxx
		LSD 5% = 1.3 mm; LSD 1% = 2.0 mm; LSD 0.1% = 3.3 mm;				LSD 5% = 1.9 mm; LSD 1% = 2.9 mm; LSD 0.1% = 4.7 mm;			

Note: x- significant, xx – distinctly significant, xxx – very significant, o – negative significant, oo – negative distinctly significant, ooo – negative very significant, LSD – Least Significant Difference. V_1 – Control (untreated), V_2 - 15 kg ha^{-1} Aquasorb, V_3 - 30 kg ha^{-1} Aquasorb.

According to the methodology proposed by I.C.PA. (Florea N., et al 1987), the bulk density results showed that the control variant was "weak loose" (BD varies between 1.19-1.31 g cm^{-3}) and the treated variants were "poorly compacted" (BD varies between 1.32-1.45 g cm^{-3}).

The plant radix was normally developed for both treated and untreated variants due to the fact that bulk density had values lower than 1.40 g cm^{-3}, being well known that those values are considered optimal for plant growth and development in a soil with clay loam texture. The *figure 3* shows the bulk density variation during the growing stages also on the 0-30 cm soil layer.



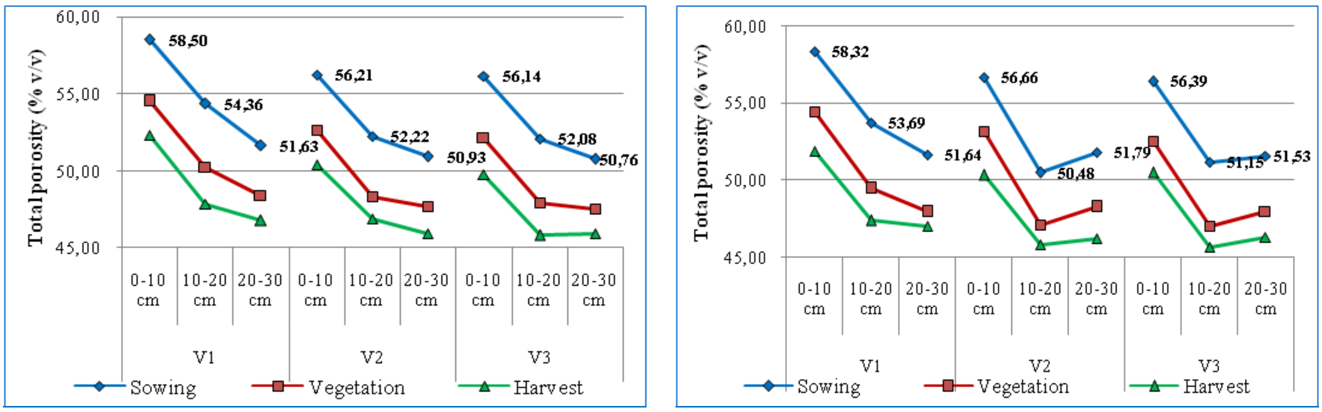
Maize Soybean

Figure 3 **The Bulk density evolution on depth and growing stages - average values 2010-2012**
V_1 – Control, V_2 – 15 kg ha^{-1} Aquasorb, V_3 – 30 kg ha^{-1} Aquasorb

Total porosity (TP)

TP has a special importance for the whole soil dynamics. To total porosity has a similar role to the solid phase because through the soils pores circulate all its organic and mineral components and which determine the analysing and interpreting of this indicator to be done depending on other important soil qualities such as, texture. Thus, a correct interpretation of this indicator according with the official methodology of pedological studies, is differentiated whereas the same values of total porosity may have different levels of favorability for plants depending on soil texture. It is appreciated that the ploughed layer is well done when the total porosity values range between 48 and 55% which 2/3 are represented by capillary pores that retain water and 1/3 by non-capillary pores that retain air (Rusu T. et al, 2007).

Averages values of TP *(table 2B)* on depth and growing stages showed that the hydrogel influenced the differentiated mode in which the soil “placed” itself under the influence of technological works executed during the growing periods, the rainfalls as well as of the own soil weight. In the hydrogel action zone were recorded higher variations compared with the ones from 20-30 cm depth layer due to the indirect influence of the soil moisture.



Maize Soybean

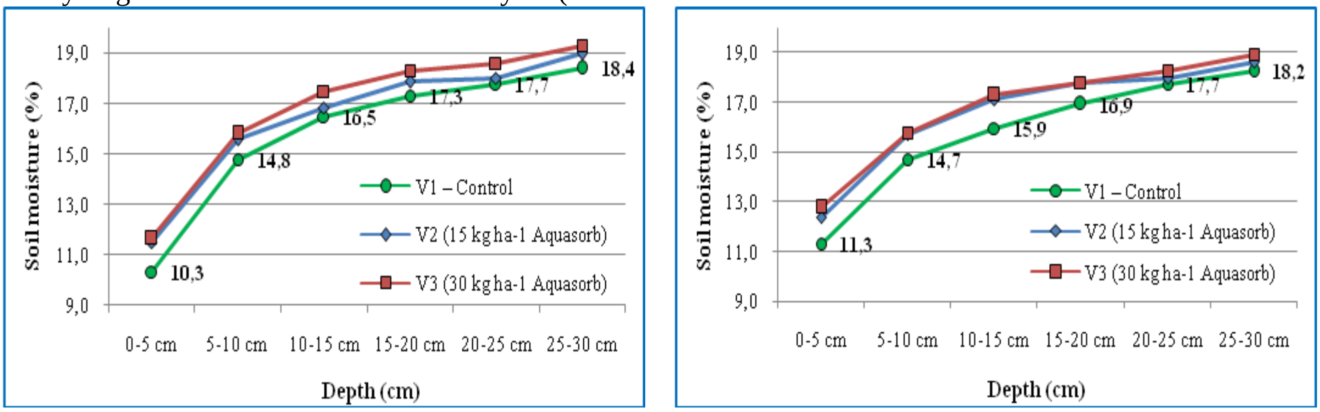
Figure 4 **Total porosity evolution on depth and growing stages - average values 2010-2012**
V_1 – Control, V_2 – 15 kg ha^{-1} Aquasorb, V_3 – 30 kg ha^{-1} Aquasorb**.**

The results interpretation according to the official methodology of pedological studies, frame the soil from the polymer treated variants and the control variant in the “weak loose” class at sowing and in “weak compacted” class during vegetation and harvesting *(figure 4)*. However, for the polymer treated variants the framing is done to a lower class limit compared with control variant.

Soil moisture

The data analysis (on depth and vegetation stages) showed that the hydrogel had a direct influence on soil moisture average values, with statistical differences noticed for both crops *(table 2C).* There were registered higher soil moisture values with 0.6-1.0% for maize culture and with 0.8-1.0% for soybean crop while to the control variant the soil moisture was in average 15.8% for both crops *(table 2).* Soil moisture was higher for the hydrogel treated variants on all soil layers (0-5 cm, 5-10 cm, 10-15 cm, 15-20 cm, 20-25 cm and 25-30 cm) in both crops *(figure 5).*

The results explain the hydrogel property to control water movement through the soil by easily retaining (blocking) the moisture and releasing it, afterwards, to the plants (Galeș D.C. et al, 2016).

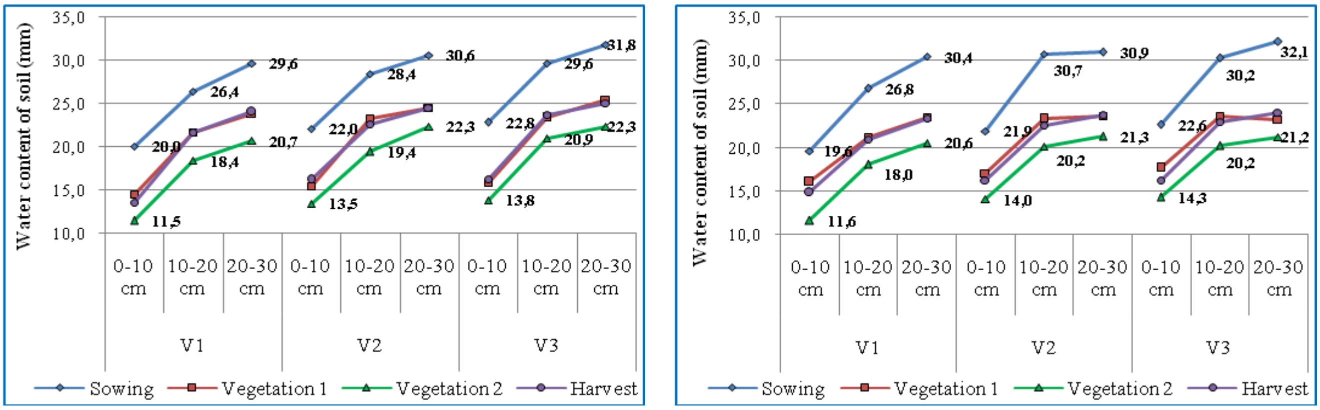


Maize Soybean

Figure 5 **Soil moisture evolution on depth - average values 2010-2012**

Soil water reserve

Soil water reserve was positively influenced by the hydrogel treatment. Thus, differences were registered between the hydrogel treated variants and the control, which ranged according with the applied Aquasorb doses between 4.3-6.3 mm for maize crop and 4.7- 5.4 mm for soybean. For the control variant, the soil water reserve varied between 61.4 mm for maize and 61.7 mm for soybean *(table 2D).* In general, soil water reserve may vary with the rainfall during the vegetation stages. Thus, for both crops were noticed higher amplitudes of soil water reserve variation after sowing and quite lower values during the driest periods of the year. For the treated variants, Aquasorb created a higher water reserve in the soil, after the spring rainfall *(figure 6).*



Maize Soybean

Figure 6 **The water reserve evolution on depth and growing stages - average values 2010-2012**
V_1 – Control, V_2 – 15 kg ha^{-1} Aquasorb, V_3 – 30 kg ha^{-1} Aquasorb

This generated water accumulation and the possibility of releasing it to the plants, according to their necessities. These results confirms prior researches (Nevenka Đurović, et al, 2012, Galeş D.C., et al, 2012, 2011, *Bhat N.R, et al, 2006,* El-Hady O.A. *et al*, 2002, Jahangir A.K. and Asadkazemi J., 2006, Nazarli H. and Zardashti M.R., 2010, Allahdadi I. *et al*, 2005, Lee Sang Soo *et al*, 2015), which supports the Aquasorb capacity of releasing water to the plants.

CONCLUSION

Applying the Aquasorb hydrogel had a direct influence on the analysed parameters, determining the increase of the bulk density, soil moisture and soil water reserve and the decrease of the total porosity.

The obtained results lead us to say that the Aquasorb has prospects to be successfully used in cultivation technologies at least for maize and soybean and possibly for other crops.

Also, that can be regarded as one of the measures to combat the negative effects of drought of average intensity or the uneven distribution of rainfall during the plant growing stages.

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