

Wheat germination and highly diluted agitated gibberellic acid (10^{-30}) – a multi researcher study

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ABSTRACT

Grains of winter wheat (*Triticum aestivum* L., Capo variety) were observed under the influence of highly diluted gibberellic acid (10^{-30}) prepared by stepwise dilution and agitation according to a protocol derived from homeopathy (“G30x”). Adequate control was used (water prepared according to the homeopathic protocol “W30x” and/or untreated water “W0”). Two sets of multicenter experiments were performed, 4 in 2009-2010 and 4 in 2011, involving altogether 6 researchers, 6 laboratories and 4,000 grains per treatment group. Data were found to be homogeneous within the control groups as well as within the *verum* groups. When the 2009-2010 experiments were pooled, mean germination rates after 24 hours were (85.9 ± 2.6) for the control group and (82.1 ± 5.7) for G30x (mean \pm SD at the level of experiments in %) (N = 2,000 per group). *Verum* germination rate was 4.4% lower than (i.e. equal to 96.6% of) ($4.4 + 96.6 = 101$) the control germination rate (100%). The difference is statistically significant ($p < 0.001$) and the effect size (d) is large (> 0.8). Observations at other points in time between 0 and 40 hours of germination yielded similar results. Practically no difference was found between W30x and W0 groups ($p > 0.05$). When the 2011 experiments were pooled, the mean germination rates after 24 hours were (73 ± 12) for the control group and (73 ± 14) for G30x (N = 2,000 per group), i.e. there was practically no difference between the groups ($p > 0.05$). We interpret the data from 2009-2010 on wheat germination within 40 hours as being in line with our previous findings on wheat stalk growth after one week, i.e. as confirmation that gibberellic acid 30x can influence, i.e. slow down, wheat development. Various possible reasons for the absence of any difference between groups in the 2011 experiments, including seasonal variance, are discussed and it is suggested to perform wheat germination experiments in the very beginning of autumn season only.

Keywords: high dilution, homeopathy, fundamental research, wheat germination, gibberellic acid

Introduction

Several authors described studies performed with wheat [1-5] as well as with diluted plant hormones prepared according to a protocol derived from homeopathy (“potentization”) [6-8]. Our previous studies [9,10] explored the influence of a high dilution of gibberellic acid (10^{-30} , “potency G30x”) on wheat development after one week. The research question was: Does treatment with G30x result in altered stalk growth of wheat seedlings measured after 7 days when compared to analogously prepared solvent water (W30x)?

Figure 1 shows the differences between the mean stalk length of G30x and W30x seedlings in 9 multicenter experiments performed in the autumn season, each one performed with 500 seedlings (Capo variety) per group. As it can be seen, all the autumn experiments on stalk length showed shorter stalks in the G30x group after 7 days. The difference is significant with $p < 0.01$ for experiments 1, 3, 4 and 8, with $p < 0.05$ for experiments 2, 5 and 9, and non-significant ($p > 0.05$) for experiments 6 and 7.

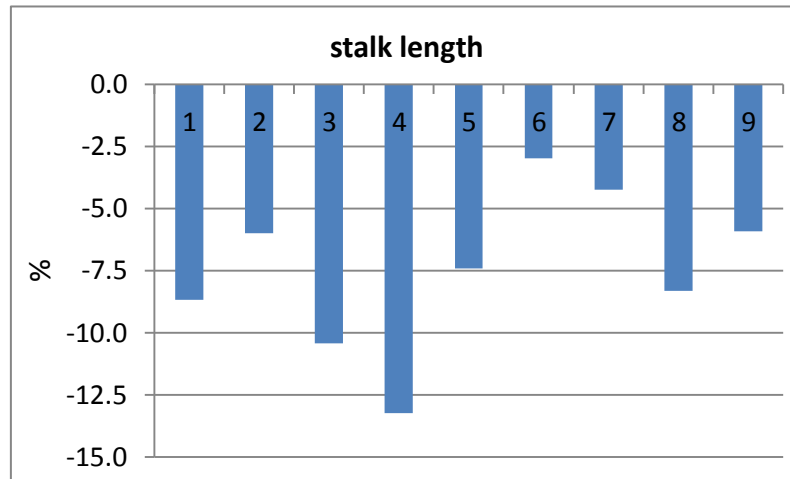


Figure 1: Wheat stalk length after 7 days in 9 multicenter experiments with high diluted agitated gibberellic acid (10^{-30} , 30x) performed in the autumn season. Relative differences in stalk length between W30x groups (zeroed) and G30x groups in percentage (ordinate). For further explanations see text. From [10], modified.

When all the experiments were pooled, the mean stalk length (mm) was (47 ± 21) in the *verum* group and (51 ± 20) in the control (mean \pm SD) at grain level (N of grains = 4,440 per group) and ± 3.87 and ± 3.38 respectively at dish level (217 dishes, i.e. cohorts of 20 or 25 grains per treatment group). In other words, *verum* stalk length was 7.28% smaller (92.72%) compared to control stalk length (100%). The effect size is small when calculated on the basis of grains ($d = 0.18$) but high when calculated on the basis of dishes ($d = 1.02$) due to the lower SD at the dish level.

In contrast, no reliable effect was found in experiments performed in winter/spring. The mean stalk length (mm) was (55 ± 16) in the *verum* group and (53 ± 14) in the control at grain level (N = 3,140 per group) and ± 4.93 and ± 3.59 respectively at dish level (152 cohorts of 20 or 25 grains per treatment group), i.e. the overall *verum* stalk length (103.64%) was 3.64% *greater* than the control stalk length (100%). The effect size is small either calculated on the basis of grains ($d = 0.13$) or of dishes ($d = 0.45$).

These results suggest that in the experiments performed in autumn, gibberellic acid 30x exerted a growth inhibiting influence. In contrast, no clear effect was found in the experiments performed in winter/spring.

As a rule, the data were found to be homogeneous within the control groups of individual experiments ($p > 0.05$) as well as within the *verum* groups ($p > 0.05$). In other words, there were significant differences between the average stalk lengths between the groups (*verum* vs. control, see above), but no significant differences within the groups. This holds true for both the autumn and the winter/spring experiments.

The aim of the study presented here was to test the influence of the high dilution of gibberellic acid compared to control on wheat germination after one day [11].

Methods

Plants

The experiments were performed on wheat grain grown without herbicides or pesticides (*Triticum aestivum* L., Capo variety), first harvest from original Z1 seed procured from Heinz organic farming, Thannhausen, Austria for experiments 1-4 and from Fritz organic farming, Weiz, Austria for experiments 5-8. Samples from both sources were evaluated by the Austrian Food Safety Authority in Vienna and found to be of similar varietal purity (> 95%). Around 10% of the grains were ruptured and around 10% were distorted, all these were removed prior to the experiment.

Researchers and sites (inter-researcher control)

The experiments were performed by 6 researchers independently at 6 different laboratories in Austria and Germany (see Table 1). Laboratory workers received thorough training in the methods and procedures to be used. They had no contact with each other while the experiments were in progress.

Laboratory conditions

All glass bottles, fastenings, plastic pipettes and Petri dishes were disposable products. Germination took place in complete darkness, interrupted by 1 or 5 15-minute intervals of light exposure per day for observation purposes as indicated in Table 1, and at temperature of $(21.0 \pm 0.2)^\circ\text{C}$ or $(20.0 \pm 0.2)^\circ\text{C}$ (see Table 1).

Preparation of test solutions

The test substance and control were prepared inspired by Baumgartner [4] using a method of stepwise dilution and succussion derived from homeopathy. The degree of dilution was set to 10^{-30} to exceed Avogadro's limit of theoretical 0-molarity. The botanic hormone 10^{-30} (30x) was chosen as an analogy to our previous experiments with a zoological hormone 30x [12].

For preparation of the test dilutions, 0.017 g of gibberellic acid (Sigma-Aldrich company, art. no. 36575) were added to 9 ml of double distilled water for experiments 1 – 4 and to 9 ml of acetone for experiments 5 – 8. The liquid was then gently swung (not “agitated”) for 1 minute (= “mother substance, 1x”). Then, using a disposable pipette (Brand company, Transferpette 100 μl), 1 ml of the mother substance was added to 9 ml of double distilled water in a 20-ml brown glass bottle (Heiland company, art. nr. 380020) and the product was agitated vigorously according to a standardized protocol: the vial was manually banged 30 times against an elastic surface at intervals of approximately 2s to create mechanical shocks (= “gibberellin 2x”). In a total of 30 steps of dilution 1:10 and 29 steps of agitation (as agitation was omitted at the first dilution step), the test substance “G30x” was thus prepared. Starting from the 29th step, quantities larger than 1 ml were added to the tenfold amount of double distilled water in order to obtain the quantities needed for the experiment. Larger brown glass bottles (each one half-filled with liquid) were used for these last steps (100 ml). A fresh glass bottle was used at each step of dilution.

As a rule, analogously prepared water (i.e. first diluted in water or acetone, respectively, and then stepwise agitated and diluted in water, W30x) was used as control to ensure that any solute material from the glass walls as well as the content of solute oxygen would be alike in gibberellic acid 30x and control 30x and thus no effects could result from the preparation method. Furthermore, untreated water (W0) was used as additional control (see table 1).

Different sets of the test and control substances were prepared by Waltraud Scherer-Pongratz (WS), Interuniversity College Graz, Austria and Christian Reich (CR) pharmacy, Braunau, Austria (table 1).

Independent probe coding

Control and *verum* were encoded by independent authorities. All the probes were applied blindly, and the codes were revealed only after the data had been calculated.

Samples

As a rule, 500 grains were observed per treatment group in each of the 8 experiments resulting a total of 4,000 grains per group. The control group of experiment 4 comprised 1,000 grains but it was accorded the same statistical weight as the others.

Table 1: Overview of experiments on wheat germination under the influence of potentized gibberellic acid (G30x) 2009-2011. exp = experiment number; researcher, see list of authors; date = time of the experiment; lab = laboratory in which the experiment was conducted; source = procurer of grains; age = age of the wheat at the time of the experiment in years; pot = person preparing the potencies; acet = acetone was used for the first step of dilution; light = exposure to light during the germination process (5 x 15': 15 minutes after 4, 8, 12, 16 and 20 hours, 1 x 15': 15 minutes after 20 hours; 24h = germination rate in the control group after 24 h; temp = temperature \pm 0.2°C. For explanations see text.

<i>exp</i>	<i>res</i>	<i>date</i>	<i>lab</i>	<i>source</i>	<i>age</i>	<i>pot</i>	<i>acet</i>	<i>light</i>	<i>24h</i>	<i>temp</i>
1	SS	2009 Sep	Weiz 1, A	Heinz	0	WS	No	5x15'	83%	21°C
2	HH	2010 Feb	Pforzheim, G	Heinz	1.5 y	WS	No	5x15'	89%	21°C
3	IS	2010 Sep	Lochau, A	Heinz	0	CR	No	1x15'	85%	21°C
4	RS	2010 Sep-Oct	Ebendorf, A	Heinz	0	CR	No	1x15'	87%	21°C
5	WM	2011 Oct	Weiz 2, A	Fritz	0	WS	yes	1x15'	65%	21°C
6	SS	2011 Oct	Weiz 2, A	Fritz	0	WS	yes	1x15'	63%	21°C
7	JH	2011 Nov	Bruchsal, G	Fritz	0	WS	yes	1x15'	90%	20°C
8	IS	2011 Nov	Lochau, A	Fritz	0	WS	yes	1x15'	72%	20.5°C

Placement of grains

The grains were placed in glass dishes (diameter 94 mm) (Greiner, Germany) each containing 1 layer of filter paper (90 mm, Macherey-Nagel, Germany) with the germination furrow faced down (figure 2).



Figure 2: Illustration of placement of grains.

Exposure to probes

Three ml of the respective probe were added to each Petri dish with the help of a disposable 5 ml syringe body (without needle). The dishes were then covered with their lids and placed in 2 cm high drawers (Viking, Germany) the bottoms of which were covered with aluminum foil (figure 3). Six or 7 dishes treated with the same probe were placed in each drawer. The drawers were arranged according to stratified randomization protocols (sequence of probes was “1-2-1-2-1-2-1-2-1-2” or “1-2-3-1-2-3-1-2-3”).

Figure 3: Illustration of setup.



Observed development (endpoint)

Germination was defined as the moment of lifting of the operculum (Fig. 4). In experiments 1 and 2, the seeds were monitored at 4-hour intervals for the first 40 hours. The results (see Results Section below) led us to assume that differences between W30x and G30x groups were largest when 80- 90% of the grains had germinated, i.e. after 24 hours.

Thus, in experiments 3-8, the seeds were monitored for germination after 24 hours. However, in experiments 5, 6 and 8 only 60-70% of grains had germinated after 24 hours, therefore, in these three experiments, the seeds were additionally monitored after 28 hours. Subsets were monitored in the same sequence as they had been planted. The measurement of endpoints was performed blindly.



Figure 4: Lifting of the operculum.

Analysis of data

The number of germinated seedlings was compared to the number of non-germinated seedlings in the *verum* and control groups in 4-field tables according to the chi-square test. Mean and SD were calculated. For pooled experiments, the effect size (Cohen's d, standardized difference of means = absolute difference between means of *verum* and control group, divided by SD) was calculated. An effect size > 0.2 is regarded as small, > 0.5 as medium and > 0.8 as large.

The homogeneity of the germination rates within the *verum* group and the control groups was investigated by one-way analysis of variance with post hoc pairwise comparisons by means of Tukey's HSD test.

Results per experiment were represented graphically by zeroing the results of the control group (preferably W30x) and plotting the difference to the G30x-groups on the ordinate.

Results

Differences within groups

The data were found to be homogeneous within the control groups ($p > 0.05$) and also within the *verum* groups ($p > 0.05$). In other words, there were no significant differences within groups.

Differences between groups

Figure 5 shows the germination rates of seedlings treated with W0, W30x and G30x at 4-hour intervals (from experiments 1+2, N = 1,000 per group). As it can be seen, there was less germination in the G30x group compared to both W0 group and W30x group at all measuring points between 20 h and 40 h.

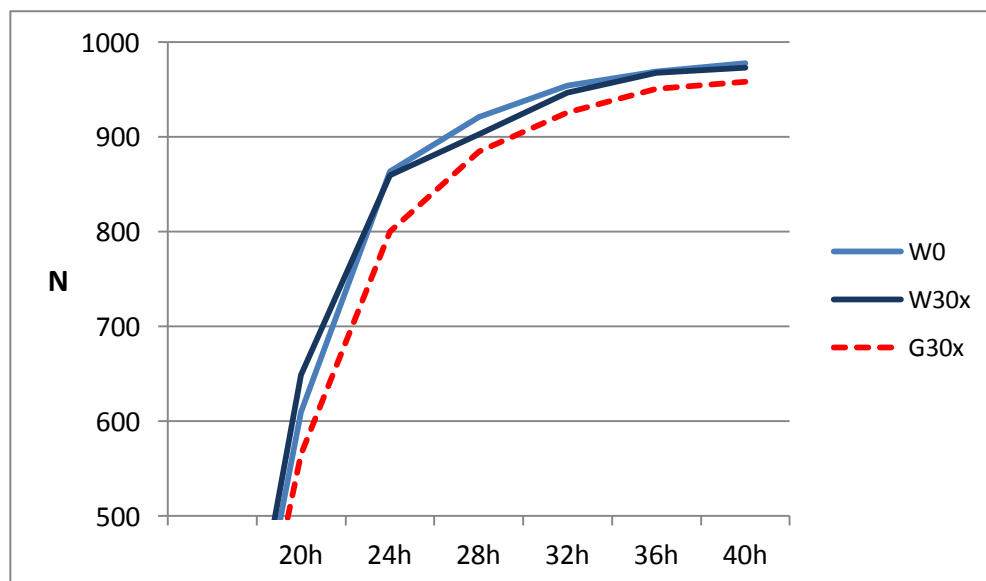


Figure 5: Germination rates in groups W0, W30x and G30x (N) at 4-hour intervals. For further explanations see text.

Table 2 shows the respective p-values of Figure 5. Differences between W0 and G30x as well as between W30x and G30x groups are significant ($p < 0.05$ or < 0.01), whereas there are no significant differences between W0 and W30x-groups.

Table 2: p-values corresponding to Figure 5.

	16h	20h	24h	28h	32h	36h	40h
W0 vs. G30x	0.631	0.041	<0.001	0.007	0.008	0.040	0.011
W30x vs. G30x	0.201	<0.001	<0.001	0.191	0.054	0.054	0.066
W0 vs. W30x	0.425	0.071	0.795	0.155	0.471	0.898	0.563

Table 3 (supplementary material) describes the details of experiments 1-8; 500 grains were used per group in each experiment.

Figure 6 shows the differences in the germination rate between control seedlings and seedlings treated with G30x in experiments 1-8 after 24 hours (above) and at the observation time-point when 80-90% of the control grains had germinated (below).

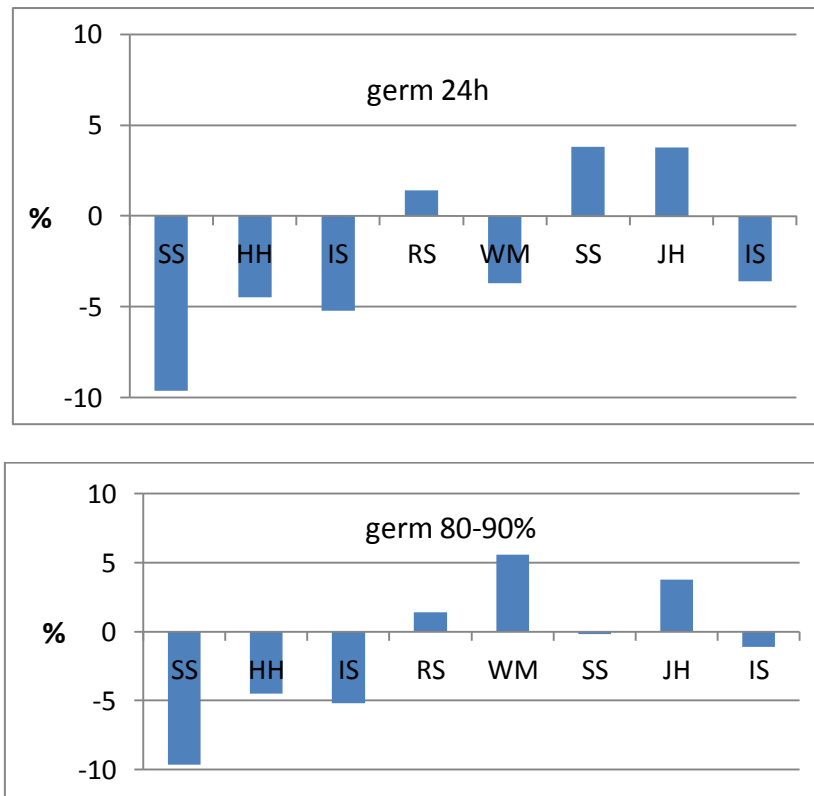


Figure 6: Relative differences in germination rates between control groups (zeroed) and G30x groups in percentage (ordinate) in experiments 1-8. For further explanations see text.

As it can be seen in Table 3 and Figure 6, the seedlings tended to show lower germination rates in the G30x groups than in the W0 groups in the initial experiments but no clear trend in the follow-up experiments. With regard to the comparison between W30x and G30x, the differences are statistically significant only in experiment 1 ($p < 0.01$), but not in experiments 3-8 ($p > 0.05$).

Table 4 (supplementary material) gives an overview on the pooled data of experiments 1-4 (2009-2010) and 5-8 (2011) as well as of all experiments 1-8.

When experiments 1-4 (2009-2010) were pooled, the mean germination rates after 24 hours (= at the observation time-point when 80-90% of the control grains had germinated) were 85.9 ± 2.6 for the control group and 82.1 ± 5.7 for G30x (mean \pm SD at the level of experiments in %) ($N = 2,000$ per group). The *verum* germination rate was 4.4% lower than (i.e. equal to 96.6% of) the control germination rate (100%). The difference is statistically significant ($p < 0.001$) and the effect size is large ($d = 0.92$).

When experiments 5-8 (2011) were pooled, the mean germination rates after 24 hours were 72.7 ± 12.4 for the control group and 72.8 ± 14.2 for G30x ($N = 2,000$ per group). The mean germination rates at the observation time-point when 80-90% of the control grains had germinated were 85.3 ± 3.5 for the control group and 87.0 ± 4.6 for G30x ($N = 2,000$ per group) ($p > 0.05$, $d = 0.01$).

Discussion

The experiments were performed on a wheat germination bioassay with a homeopathic high dilution of gibberellic acid.

Grains of winter wheat (*Triticum aestivum* L., Capo variety) were observed under the influence of highly diluted gibberellic acid (10^{-30}) prepared by stepwise dilution and agitation according to a protocol derived from homeopathy ("G30x"). Adequate control was used (water prepared according to the homeopathic protocol "W30x" and/or untreated water "W0"). Two sets of multicenter experiments were performed, 4 in 2009-2010 and 4 in 2011, involving altogether 6 researchers, 6 laboratories and 4,000 grains per treatment group.

The data were found to be homogeneous within the control groups as well as within the *verum* groups. When the 2009-2010 experiments were pooled, the mean germination rates after 24 hours were 85.9 ± 2.6 for the control group and 82.1 ± 5.7 for G30x (mean \pm SD at the level of experiments in %) ($N = 2,000$ per group). The *verum* germination rate was 4.4% lower than (i.e. equal to 96.6% of) ($4,4 + 96,6 = 101$) the control germination rate (100%). The difference is statistically significant ($p < 0.001$) and the effect size (d) is large (> 0.8). Observations at other time-points between 0 and 40 hours of germination yielded similar results. Practically no difference was found between the W30x and W0 groups ($p > 0.05$).

When the 2011 experiments were pooled, the mean germination rates after 24 hours were 72.7 ± 12.4 for the control group and 72.8 ± 14.2 for G30x ($N = 2,000$ per group), i.e. there was practically no difference between the groups ($p > 0.05$).

We interpret the data from 2009-2010 on wheat germination within 40 hours as being in line with our previous findings on wheat stalk growth after one week, i.e. as confirmation that gibberellic acid 30x can influence, i.e. slow down, wheat development. The following discussion of possible reasons for the absence of any observable effect in the 2011 experiments (see Table 1) may offer ideas for optimizing the present bioassay.

Researchers: So-called “researcher effect” may be excluded, as SS took part in both phases of the study, with significant result in 2009 and no difference between groups in 2011.

Person who provided the potencies: A “person effect” may be excluded, as WS took part in both stages of the study.

Source: The Capo variety grains used in 2011 were procured from a new source due to supply difficulties with the previous one. However, they were similar to the earlier batch in terms of geographic origin and purity.

Age: With the exception of experiment 2, the grains were in each case from the latest harvest, thus excluding loss of sensitivity due to storage. However, this also means that they were from different harvest years.

Germination: If it is assumed that the researchers differed slightly in their judgment as to when the endpoint, i.e. germination, had occurred, the most valid comparisons are those between experiments 3 and 8 (IS) and 1 and 6 (SS). Another possible factor of influence here is the striking difference in the germination rate. The grains of 2011 seemingly had lower viability than those of previous years. Differences in sensitivity to potentized gibberellic acid attributable to differences in seed maturity, starch content etc. would be in line with the findings by Baumgartner et al. [7].

Date: Experiments 1, 2 and 3 (showing less germination in the G30x than in the control groups) were performed in September or in February (i.e. close to the natural germination period) whereas experiments 5-8 were performed in October and November. This speaks in favor of planning further repetitions of the experiment in September or February (northern hemisphere), and points to the same direction as previous findings on wheat stalk growth after one week that showed more promise for experiments on wheat grain sensitivity to G30x performed in the autumn compared to the winter season [10]. Whereas for the focus on stalk growth, September to November seems to be suitable a period, for the focus on germination (in the northern hemisphere only September may be suitable).

Acetone: Acetone was used in the potentization process in 2011, but not in 2009-2010. At first sight, this makes it a likely candidate for explaining the differences between the phases parts of the study. However, our motivation to use acetone as solvent for gibberellic acid in the mother substance in the first place came from the results of our 1-week experiments on wheat stalk growth [10], where it seemed to stabilize the inhibiting effect of G30x compared to water analogously prepared from a mother substance including acetone.

Light: The grains were grown in darkness, interrupted only by 15-minute intervals of light for observation purposes. In experiments 1 and 2, light was used 5 times 15 minutes, after 4, 8, 12, 16 and 20 hours, in experiments 3-5 once after 20 hours prior to the observation at 24 (and 28) hours, and in experiments 6-8 only after 24 hours. It may be interesting to investigate the influence of light on the wheat grain sensitivity to G30x.

Our present results point to the wheat and gibberellic acid model as a promising candidate for future research. For the time being, we suggest independent repetitions of the study on 1-week wheat stalk growth and G30x [9,10] (preferably in the autumn season), whereas we will seek to standardize better the one-day wheat germination model with G30x. This should include an automatic computerized monitoring system as well as experiments with other plant hormones (e.g. abscisic acid - ABA).

In view of the ease of handling and procuring the necessary disposable materials as well as the shortness of the experimental period (1 day), we consider the wheat germination assay as suited to pursuing further research topics in ultra high dilution, such as issues on the preparation, transport and storage of homeopathic potencies. Whatever findings might be obtained, they might be substantiated in a later stage by means of experiments on the stalk length bioassay (7 days) [9,10].

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Supplementary Material

Table 3: Individual experiments 1-8 listed in Table 1, germination rates after 24 hours and at the time-point when 80-90% of grains had germinated, i.e. after 24 or 28 hours. Exp = experiment; initials SS, HH, IS, RS, WM, JH see list of authors; 24h, 28h = observation time-points; germ = percentage of germinated seedlings at the observation time-points; sum = number of germinated grains in the respective groups (total: 500 grains per group); mean \pm SD of a total of 20 grains per dish; W0, W30x, G30x = treatment groups; Δ = difference in germinated G30x grains relative to the control group (W30x where available); p W0: = significance level of the difference relative to the W0 group; p W30x = relative to the W30x group.

<i>exp</i>			<i>W0</i>	<i>W30x</i>	<i>G30x</i>
1	SS, 24h	<i>sum</i>	406	415	375
	germ=83%	<i>Mean \pmSD</i>		16.0 \pm 1.8	15.0 \pm 1.8
		%	97.8	100	90.4
		<i>p W0:</i>		> 0.05	< 0.05
		<i>p W30x:</i>	> 0.05		< 0.01
2	HH, 24h	<i>sum</i>	458	445	425
	germ=89%	<i>Mean \pmSD</i>		17.8 \pm 1.5	17.0 \pm 2.
		%	102.9	100	95.5
		<i>p W0:</i>		> 0.05	< 0.01
		<i>p W30x:</i>	> 0.05		> 0.05
3	IS, 24h	<i>sum</i>	423		401
	germ=85%	<i>Mean \pmSD</i>	17.0 \pm 2.1		16.0 \pm 2.4
		%	100		94.8
		<i>p W0:</i>			> 0.05
4	RS, 24h	<i>sum</i>	434		440
	germ=87%	<i>Mean \pmSD</i>	17.04 \pm 2.6		17.6 \pm 2.2
		Δ W0 (%)	100		101.4
		<i>p W0:</i>			> 0.05
5	WM, 24h			325	313
	germ=65%			13 \pm 2.1	12,5 \pm 2.0
				100	96.3
		<i>p W30x:</i>			> 0.05

5	WM, 28h	<i>sum</i>	410	434
	germ=82%	<i>Mean ±SD</i>	16.4±1.9	17.4±1.5
		%	100	105.6
		<i>p W30x:</i>		> 0.05
6	SS, 24h	<i>sum</i>	315	327
	germ=63%	<i>Mean ±SD</i>	12.6±1.83	13.08±1.5
		%	100	103.8
		<i>p W30x:</i>		> 0.05
6	SS, 28h	<i>sum</i>	422	421
	germ=84%	<i>Mean ±SD</i>	16.9±1.7	16.8±1.4
		%	100	99.8
		<i>p W30x:</i>		> 0.05
7	JH, 24h	<i>sum</i>	451	468
	germ=90%	<i>Mean ±SD</i>	18.0±1.5	18.7±1.0
		%	100	103.8
		<i>p W30x:</i>		> 0.05
8	IS, 24h	<i>sum</i>	360	347
	germ=72%	<i>Mean ±SD</i>	14.4±2.9	13.9±1.8
		%	100	96.4
		<i>p W30x:</i>		> 0.05
8	IS, "26"h	<i>sum</i>	422	417.5
	germ=85%	<i>mean±S.D.</i>		
		%	100	98,9
		<i>p W30x:</i>		> 0.05
8	IS, 28h	<i>sum</i>	484	488
	germ=97%	<i>Mean ±SD</i>	19.36±0.9	19.52±0.6
		%	100	100,8
		<i>p W30x:</i>		> 0.05

Table 4: Pooled data from experiments listed in Table 1, germination rate after 24 hours (above) and at the observation time-point when 80-90% of the control grains had germinated (below). SD is given at the level of experiments. For explanations, see legend to Table 3 and text.

nr.	[germ. = 24h]	W	G30x
1+2+3+4	<i>sum [2000]</i>	1717	1641
	<i>Mean ±SD</i>	429.3±13.1	410.3±28.5
	<i>Mean ±SD in %</i>	85.9±2.6	82.1±5.7
	%	100	95.6%
	<i>p:</i>		< 0.001

5+6+7+8	<i>sum [2000]</i>	1451	1455
	<i>Mean ±SD</i>	362.8±61.9	363.75±70.9
	<i>Mean ±SD in %</i>	72.7±12.4	72.8±14.2
	%	100	100.3
	<i>p:</i>		> 0.05

1 - 8	<i>sum [4000]</i>	3168	3096
	<i>Mean ±SD</i>	396±54.6	387±55.8
	<i>Mean ±SD in %</i>	79.2±10.9	77.4±11
	%	100	97.7
	<i>p:</i>		> 0.05

nr.	[germ. – 80-90%]	W	G30x
1+2+3+4	<i>sum [2000]</i>	1717	1641
	<i>Mean ±SD</i>	429.3±13.1	410.3±28.5
	<i>Mean ±SD in %</i>	85.9±2.6	82.1±5.7
	%	100	95.57%
	<i>p:</i>		< 0.001

5+6+7+8	sum [2000]	1705	1741
	Mean \pm SD	426.3 \pm 7.4	435.1 \pm 23.0
	Mean \pm SD in %	85.3 \pm 3.5	87.0 \pm 4.6
	%	100	102.11
	p:		> 0.05

1 - 8	sum [4000]		
	Mean \pm SD	427.8 \pm 14.4	422.7 \pm 27.4
	Mean \pm SD in %	85.6 \pm 2.9	84.59 \pm 5.5
	%	100	98.8
	p:		> 0.05

Germinação do trigo e ácido giberélico em alta diluição (10^{-30}) e agitado – um estudo multicêntrico

RESUMO

Grãos de trigo comum (*Triticum sativum* L., variedade Capó) foram observados sob a influência de uma alta diluição de ácido giberélico (10^{-30}) preparada através de diluição e agitação seriadas seguindo um protocolo derivado da homeopatia (G30x). Foram utilizados controles adequados (água preparada segundo o protocolo homeopático - W30x - e/ou água sem tratamento - W0 -). Foram realizadas duas séries de experimentos multicêntricos, 4 em 2009-2010 e 4 em 2011, incluindo 6 pesquisadores, 6 laboratórios, e 4.000 grãos em cada grupo de tratamento. Os dados foram homogêneos dentro dos grupos controle e *verum*. Na análise combinada dos experimentos de 2009-2010, as taxas médias de germinação em 24 h foram (85,9 \pm 2,6) no grupo controle e (82,1 \pm 5,7) no grupo G30x (média \pm DP no nível dos experimentos em %, N = 2.000 por grupo). A taxa de germinação de *verum* foi 4,4% menor (96,6% de 4,4 + 96,6 = 101) que a do controle (100%). Essa diferença é estatisticamente significativa ($p < 0,001$) e o tamanho do efeito (d) é grande ($> 0,8$). Observações realizadas em outros momentos entre 0 e 40 horas de germinação constaram resultados similares. Praticamente, não foi achada diferença entre os grupos W30x e W0 ($p > 0,05$). Na análise combinada dos experimentos de 2011, as taxas médias de germinação em 24 h foram (73 \pm 12) no grupo controle e (73 \pm 14) no grupo G30x (N = 2.000 por grupo), ou seja, praticamente não houve diferença entre os grupos ($p > 0,05$). Consideramos que os dados de 2009-2010 sobre a germinação do trigo em até 40 h concordam com nos achados prévios no crescimento do caule de trigo em uma semana, ou seja, confirmam que ácido giberélico 30x pode influenciar, isto é, tornar mais lento, o desenvolvimento do trigo. São discutidos vários motivos para a ausência de toda diferença entre os grupos nos experimentos conduzidos em 2011, incluindo variações sazonais, e sugere-se que os experimentos com germinação de trigo sejam realizados exclusivamente no começo do outono.

Palavras-chave: alta diluição, homeopatia, pesquisa básica, germinação do trigo, ácido giberélico

Germinación de trigo y ácido giberélico en alta dilución (10^{-30}) y agitado – estudio multicéntrico

RESUMEN

Fueron observados granos de trigo común (*Triticum sativum* L., variedad Capo) bajo influencia de alta dilución de ácido giberélico (10^{-30}) preparada por dilución y agitación seriadas según protocolo derivado de la homeopatía (G30x). Fueron utilizados controles adecuados (agua preparada según el protocolo homeopático, -W30x -, y/o agua sin tratamiento – W0 -). Fueron realizadas dos series de experimentos multicéntricos, 4 en 2009-2010 y 4 en 2011, comprendiendo 6 investigadores, 6 laboratorios y 4.000 granos en cada grupo de tratamiento. Los datos se mostraron homogéneos dentro de los grupos control y *verum*. En el análisis combinado de los experimentos de 2009-2010, la tasa promedio de germinación en 24 horas fue ($85,9 \pm 2,6$) en el grupo control y ($82,1 \pm 5,7$) en el grupo G30x (media \pm DE en el nivel de experimentos en %, N = 2.000 por grupo). La tasa promedio de germinación del *verum* fue 4,4% menor ($96,6\%$ de $4,4 + 96,6 = 101$) que la del control (100%). Esta diferencia es estadísticamente significativa ($p < 0,001$) y el tamaño del efecto (d) es grande ($> 0,8$). Observaciones realizadas en otros momentos entre 0 y 40 horas de germinación constaron resultados similares. Prácticamente no hubo diferencia entre los grupos W30x y W0 ($p > 0,05$). En el análisis combinado de los experimentos de 2011, la tasa promedio de germinación en 24 h fue ($73 + 12$) en el grupo control y ($73 + 14$) en el grupo G30x (N = 2.000 por grupo), o sea, prácticamente no hubo diferencia entre los grupos ($p > 0,05$). Consideramos que los datos de 2009-2010 sobre germinación de trigo en 40 h concuerdan con los resultados anteriores sobre crecimiento de tallo de trigo en una semana, o sea, confirman que el ácido giberélico 30x puede influenciar, es decir, enlentecer, el desarrollo del trigo. Se discuten varios motivos de la total falta de diferencia entre grupos en los experimentos realizados en 2011 incluyendo variaciones estacionales, y se sugiere que experimentos de germinación de trigo sean exclusivamente realizados al principio del otoño.

Palabras clave: alta dilución, homeopatía, investigación básica, germinación de trigo, ácido giberélico



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Support: authors declare that this study received no funding

Conflict of interest: authors declare there is no conflict of interest

Received: 24 April 2012; Revised: 22 June 2012; Published: 30 June 2012.

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How to cite this article: Kiefer P, Matzer W, Schiestl S, Hartung H, Schwärzler I, Seunig R, Hofäcker J, Endler PC. Wheat germination and highly diluted agitated gibberellic acid (10^{-30}) – a multi researcher study. Int J High Dilution Res [online]. 2012 [cited YYYY Month dd]; 11(39): 45-59. Available from: <http://www.feg.unesp.br/~ojs/index.php/ijhdr/article/view/428/560>