

Supplementary Material

Silver nanoparticles affect wheat (*Triticum aestivum*L.) germination, seedling blight and yield

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SUPPLEMENTARY MATERIAL

Table S1 Chosen physicochemical properties of AgNPs and their stock suspensions

Property [unit]	TCSB-AgNPs	SHSH-AgNPs
compounds used for the AgNP preparation	trisodium citrate, sodium borohydride	sodium hexametaphosphate, sodium hypophosphite
mass concentration of AgNPs in the stock suspension [mg L^{-1}]	123	145
conductivity of stock AgNPs suspension [$\mu\text{S cm}^{-1}$]	5.7	3.9
pH of stock suspension	6.2	6.3
plasmon absorption maximum [nm]	394	393
size of AgNPs [nm] determined based on TEM	15 \pm 4	13 \pm 4
diffusion coefficient of AgNPs [$\times 10^{-7} \text{ cm}^2\text{s}^{-1}$] at temperature of 25°C	2.68 \pm 0.2	3.77 \pm 0.2
hydrodynamic diameter of AgNPs [nm]	16 \pm 4	13 \pm 4
polidispersity index (PDI)	0.25	0.31
electrophoretic mobility [$\mu\text{mcm (Vs)}^{-1}$] at temperature of 25°C	-3.15 \pm 0.29	-2.83 \pm 0.15
zeta potential [mV] at temperature of 25°C	-66 \pm 3	-54 \pm 2
concentration of leached silver ions from the AgNPs dispersed in 10 mg L^{-1} suspensions of DO concentration 6.9–7.2 mg L^{-1} and at temperature of 25°C after:		
0 day (after the suspension purification)	0	0
1 day (24 h)	0.11 \pm 0.08	0.43 \pm 0.01
10 days	0.63 \pm 0.05	1.04 \pm 0.06
30 days	0.68 \pm 0.11	1.53 \pm 0.04

Table S2 The effect of AgNPs and silver ions delivered in the form of AgNO₃ on the efficiency of photosystem II of common wheat after 3rd, 4th, 5th, 6th and 7th week of treatment. Values represent means ± SE. Values marked with the same letters (within parameters) are not significantly different at p ≤ 0.05.

Treatment	F _v /F _m	PI	ABS/CS	TR _o /CS	ET _o /CS	DI _o /CS	RC/CS _o	RC/CS _m	ψ _o	φE _o	OEC
3rd week											
Control	0.820 ± 0.002 d	1.089 ± 0.040 d	374.100 ± 6.144 ab	306.676 ± 4.959 ab	119.025 ± 2.677 c	67.539 ± 1.590 a	150.372 ± 6.183 a	815.028 ± 19.386 c	0.450 ± 0.010 c	0.367 ± 0.008 cd	0.523 ± 0.008 c
Silver ions 30 ^A	0.827 ± 0.001 d	1.551 ± 0.044 cd	336.000 ± 14.588 c	277.709 ± 12.022 c	126.743 ± 5.129 bc	58.291 ± 2.708 a	145.307 ± 5.169 a	800.902 ± 42.364 c	0.408 ± 0.014 d	0.329 ± 0.011 d	0.544 ± 0.006 bc
TCSB-AgNPs 10	0.835 ± 0.001 ab	2.055 ± 0.065 a	389.200 ± 5.549 ab	332.408 ± 4.780 a	148.192 ± 2.524 a	67.027 ± 1.082 a	164.412 ± 7.080 a	967.336 ± 40.639 a	0.490 ± 0.007 ab	0.411 ± 0.006 a	0.573 ± 0.007 a
TCSB-AgNPs 20	0.835 ± 0.002 ab	1.976 ± 0.110 ab	394.400 ± 8.429 ab	329.038 ± 6.584 ab	150.595 ± 4.107 a	65.362 ± 2.014 a	160.288 ± 3.976 a	948.712 ± 16.127 ab	0.479 ± 0.110 a-c	0.398 ± 0.008 ab	0.566 ± 0.007 ab
TCSB-AgNPs 30	0.838 ± 0.001 a	2.107 ± 0.071 a	400.900 ± 12.196 a	335.974 ± 10.286 a	165.170 ± 6.856 a	64.926 ± 1.998 a	168.797 ± 5.039 a	1042.740 ± 33.611 a	0.462 ± 0.006 bc	0.416 ± 0.006 a	0.562 ± 0.003 ab
SHSH-AgNPs 10	0.829 ± 0.003 bc	1.871 ± 0.115 ab	400.800 ± 17.609 ab	322.197 ± 15.187 ab	159.032 ± 8.193 a	68.392 ± 2.773 a	154.453 ± 15.060 a	924.366 ± 93.590 ab	0.498 ± 0.005 a	0.397 ± 0.008 ab	0.582 ± 0.015 a
SHSH-AgNPs 20	0.083 ± 0.001 bc	1.759 ± 0.052 bc	358.000 ± 29.515 bc	298.922 ± 24.761 bc	148.997 ± 12.730 a	59.078 ± 4.778 a	154.535 ± 7.385 a	938.780 ± 47.102 ab	0.479 ± 0.009 a-c	0.384 ± 0.004 bc	0.558 ± 0.006 ab
SHSH-AgNPs 30	0.828 ± 0.002 cd	1.678 ± 0.135 bc	369.800 ± 36.895 a-c	307.931 ± 30.807 ab	146.185 ± 14.765 ab	61.869 ± 6.127 a	154.967 ± 5.991 a	834.756 ± 49.219 bc	0.458 ± 0.009 c	0.382 ± 0.010 bc	0.546 ± 0.010 bc
4th week											
Control	0.779 ± 0.003 a-c	0.977 ± 0.065 a-c	399.000 ± 9.529 bc	312.943 ± 7.351 a	152.070 ± 4.194 bc	86.072 ± 2.623 c	111.412 ± 3.348 c	427.382 ± 30.182 cd	0.481 ± 0.012 a	0.365 ± 0.021 bc	0.402 ± 0.009 d
Silver ions 30	0.738 ± 0.004 e	0.926 ± 0.042 b-d	395.500 ± 12.929 c	306.254 ± 9.130 a	148.746 ± 3.581 c	85.441 ± 2.889 c	106.422 ± 3.438 c	398.210 ± 11.843 d	0.468 ± 0.021 a	0.339 ± 0.011 c	0.379 ± 0.042 d

TCSB-AgNPs 10	0.797 ± 0.004 a	1.378 ± 0.051 a	498.222 ± 11.681 a	312.045 ± 3.047 a	188.027 ± 4.562 a	128.206 ± 9.779 ab	135.248 ± 3.796 a	603.238 ± 12.217 ab	0.518 ± 0.017 a	0.406 ± 0.015 ab	0.484 ± 0.008 ab
TCSB-AgNPs 20	0.785 ± 0.006 a	1.142 ± 0.140 ab	416.800 ± 14.402 bc	332.848 ± 9.847 a	164.107 ± 4.983 ab	119.390 ± 4.264 b	135.536 ± 1.157 a	654.676 ± 4.723 a	0.501 ± 0.029 a	0.397 ± 0.015 ab	0.496 ± 0.011 a
TCSB-AgNPs 30	0.784 ± 0.009 ab	1.087 ± 0.173 ab	418.000 ± 15.344 bc	326.971 ± 8.962 a	152.353 ± 6.484 bc	94.740 ± 5.978 bc	132.081 ± 3.790 ab	602.890 ± 15.358 ab	0.496 ± 0.017 a	0.369 ± 0.020 bc	0.439 ± 0.021 cd
SHSH-AgNPs 10	0.763 ± 0.004 cd	0.727 ± 0.087 d	440.200 ± 14.590 b	333.783 ± 6.498 a	151.652 ± 9.727 bc	175.217 ± 16.185 a	117.601 ± 3.851 c	478.576 ± 28.530 cd	0.542 ± 0.021 a	0.415 ± 0.010 a	0.445 ± 0.013 b-d
SHSH-AgNPs 20	0.764 ± 0.007 b-d	0.928 ± 0.117 bc	433.800 ± 31.850 bc	307.752 ± 18.585 a	179.741 ± 13.643 ab	126.048 ± 16.238 ab	118.051 ± 5.836 bc	531.785 ± 38.715 bc	0.544 ± 0.020 a	0.379 ± 0.013 a-c	0.474 ± 0.026 a-c
SHSH-AgNPs 30	0.750 ± 0.005 de	0.757 ± 0.065 cd	427.444 ± 17.417 bc	308.054 ± 11.104 a	152.512 ± 10.389 bc	85.906 ± 9.168 c	113.047 ± 5.777 c	468.777 ± 24.804 cd	0.484 ± 0.021 a	0.365 ± 0.019 bc	0.405 ± 0.031 cd

5th week

Control	0.826 ± 0.002 ab	1.701 ± 0.140 bc	346.500 ± 5.330 cd	286.215 ± 4.323 a	144.176 ± 5.112 bc	60.231 ± 1.446 de	120.235 ± 1.746 b	637.020 ± 12.637 cd	0.503 ± 0.013 d	0.404 ± 0.009 d	0.480 ± 0.009 c
Silver ions 30	0.807 ± 0.005 c	1.417 ± 0.094 c	339.800 ± 16.266 d	274.458 ± 13.425 a	138.361 ± 8.127 c	58.359 ± 3.333 e	119.033 ± 2.930 b	614.848 ± 10.992 d	0.501 ± 0.011 d	0.417 ± 0.013 cd	0.472 ± 0.009 c
TCSB-AgNPs 10	0.832 ± 0.001 a	2.352 ± 0.118 a	359.700 ± 2.191 a-c	289.641 ± 1.687 a	161.051 ± 2.265 a	65.297 ± 0.621 bc	131.278 ± 1.459 a	785.833 ± 13.175 a	0.566 ± 0.010 a	0.469 ± 0.009 a	0.535 ± 0.007 a
TCSB-AgNPs 20	0.822 ± 0.004 b	1.979 ± 0.127 ab	360.600 ± 6.938 ab	296.157 ± 4.086 a	162.424 ± 5.414 a	71.720 ± 2.891 ab	126.090 ± 1.573 ab	706.199 ± 18.527 b	0.548 ± 0.012 a-c	0.450 ± 0.009 ab	0.522 ± 0.008 ab
TCSB-AgNPs 30	0.822 ± 0.002 b	1.789 ± 0.070 b	366.556 ± 4.364 a	294.223 ± 3.296 a	163.575 ± 3.238 a	72.333 ± 1.589 a	130.468 ± 1.576 a	686.019 ± 21.470 b	0.519 ± 0.011 b-d	0.420 ± 0.009 b-d	0.482 ± 0.005 c
SHSH-AgNPs 10	0.824 ± 0.003 b	1.830 ± 0.107 b	357.100 ± 2.762 a-d	294.016 ± 1.520 a	147.885 ± 4.257 bc	63.084 ± 1.386 cd	124.981 ± 2.746 b	696.625 ± 14.705 b	0.550 ± 0.009 ab	0.446 ± 0.006 a-c	0.486 ± 0.011 c
SHSH-AgNPs 20	0.810 ± 0.001 c	1.472 ± 0.063 c	358.600 ± 3.041 a-d	295.101 ± 2.174 a	155.705 ± 2.891 ab	63.499 ± 0.971 cd	122.857 ± 1.645 b	694.076 ± 6.663 b	0.527 ± 0.008 b-d	0.434 ± 0.006 bc	0.497 ± 0.006 bc
SHSH-AgNPs 30	0.807 ± 0.004 c	1.653 ± 0.063 bc	348.000 ± 2.692 b-d	296.680 ± 6.057 a	152.685 ± 6.096 a-c	64.443 ± 3.313 b-d	122.709 ± 1.312 b	680.622 ± 13.541 bc	0.508 ± 0.014 cd	0.414 ± 0.010 cd	0.486 ± 0.009 c

6 th week											
Control	0.778 ± 0.014 bc	1.327 ± 0.108 c	364.200 ± 5.727 ab	291.659 ± 3.393 ab	143.120 ± 4.536 b	75.147 ± 3.157 a	112.139 ± 2.872 c	557.221 ± 14.029 c	0.467 ± 0.013 c	0.385 ± 0.016 bc	0.468 ± 0.031 cd
Silver ions 30	0.766 ± 0.006 c	1.281 ± 0.093 c	346.000 ± 3.187 c	281.207 ± 3.584 b	142.247 ± 1.616 b	71.455 ± 1.518 a	102.860 ± 12.024 c	548.073 ± 41.188 c	0.458 ± 0.023 c	0.375 ± 0.012 c	0.450 ± 0.022 d
TCSB-AgNPs 10	0.812 ± 0.008 a	1.965 ± 0.236 a	381.300 ± 12.989 a	300.250 ± 5.162 a	174.966 ± 6.892 a	84.408 ± 7.954 a	132.999 ± 4.034 a	627.835 ± 39.156 bc	0.590 ± 0.022 a	0.463 ± 0.021 a	0.540 ± 0.030 a
TCSB-AgNPs 20	0.807 ± 0.009 ab	1.935 ± 0.286 a	370.000 ± 5.160 a	293.056 ± 2.497 a	140.111 ± 2.359 b	77.331 ± 3.006 a	127.866 ± 2.439 ab	702.153 ± 17.603 a	0.534 ± 0.009 b	0.458 ± 0.011 a	0.531 ± 0.039 ab
TCSB-AgNPs 30	0.795 ± 0.006 ab	1.554 ± 0.176 a-c	383.300 ± 10.936 a	300.999 ± 6.196 a	163.255 ± 3.032 a	79.432 ± 4.243 a	129.118 ± 1.572 ab	599.704 ± 26.910 bc	0.544 ± 0.013 ab	0.429 ± 0.013 ab	0.500 ± 0.016 a-d
SHSH-AgNPs 10	0.814 ± 0.008 a	1.799 ± 0.144 ab	370.400 ± 6.032 a	298.091 ± 3.982 a	162.370 ± 6.454 a	74.842 ± 1.947 a	129.238 ± 3.430 a	682.039 ± 28.743 ab	0.550 ± 0.018 ab	0.447 ± 0.015 a	0.518 ± 0.011 a-c
SHSH-AgNPs 20	0.792 ± 0.004 ab	1.423 ± 0.082 bc	362.700 ± 4.201 ab	291.159 ± 2.805 ab	162.290 ± 4.673 a	68.916 ± 2.017 a	115.238 ± 2.644 c	567.486 ± 21.944 c	0.564 ± 0.012 ab	0.423 ± 0.010 a-c	0.500 ± 0.014 a-d
SHSH-AgNPs 30	0.803 ± 0.006 ab	1.338 ± 0.104 c	351.100 ± 4.500 bc	281.626 ± 2.898 b	137.721 ± 1.550 b	69.824 ± 2.219 a	118.853 ± 4.222 bc	581.332 ± 32.926 c	0.483 ± 0.019 c	0.391 ± 0.016 bc	0.494 ± 0.018 b-d
7 th week											
Control	0.819 ± 0.008 a	1.867 ± 0.190 b-d	341.100 ± 7.054 ab	278.875 ± 3.334 bc	143.750 ± 5.176 bc	62.281 ± 4.201 a	128.626 ± 4.535 bc	673.961 ± 35.703 c	0.521 ± 0.014 a	0.414 ± 0.013 bc	0.521 ± 0.021 b
Silver ions 30	0.809 ± 0.007 a	1.634 ± 0.164 d	307.500 ± 15.927 b	248.800 ± 12.730 c	130.608 ± 8.272 c	58.702 ± 3.848 a	120.749 ± 4.553 c	644.740 ± 50.038 c	0.464 ± 0.019 b	0.400 ± 0.012 c	0.512 ± 0.021 b
TCSB-AgNPs 10	0.820 ± 0.006 a	2.415 ± 0.148 a	356.200 ± 8.314 a	291.561 ± 4.825 a	160.107 ± 4.349 a	64.639 ± 3.940 a	146.883 ± 2.740 a	806.799 ± 17.853 a	0.529 ± 0.011 a	0.454 ± 0.006 a	0.577 ± 0.005 a
TCSB-AgNPs 20	0.822 ± 0.003 a	2.172 ± 0.136 ab	347.889 ± 3.942 a	285.764 ± 2.586 ab	146.583 ± 3.920 a-c	62.125 ± 1.590 a	143.125 ± 2.101 a	815.879 ± 40.625 a	0.529 ± 0.016 a	0.435 ± 0.017 ab	0.583 ± 0.010 a
TCSB-AgNPs 30	0.825 ± 0.004 a	2.396 ± 0.161 ab	342.556 ± 6.949 a	289.096 ± 4.571 a	147.437 ± 5.231 a-c	60.156 ± 2.542 a	138.520 ± 2.793 ab	755.807 ± 21.850 a-c	0.528 ± 0.018 a	0.431 ± 0.010 a-c	0.561 ± 0.010 ab

SHSH-AgNPs 10	0.826 ± 0.005 a	2.028 ± 0.274 a-d	345.400 ± 5.038 a	285.026 ± 2.630 ab	154.977 ± 4.387 ab	60.374 ± 2.597 a	138.176 ± 4.883 ab	800.594 ± 39.841 ab	0.553 ± 0.009 a	0.449 ± 0.013 ab	0.556 ± 0.015 ab
SHSH-AgNPs 20	0.821 ± 0.005 a	2.094 ± 0.128 a-c	352.400 ± 5.392 a	282.399 ± 3.188 ab	154.295 ± 3.544 ab	63.304 ± 2.518 a	133.647 ± 1.424 bc	738.860 ± 24.044 a-c	0.528 ± 0.011 a	0.434 ± 0.011 a-c	0.553 ± 0.008 ab
SHSH-AgNPs 30	0.819 ± 0.005 a	1.709 ± 0.176 cd	341.600 ± 6.363 ab	279.415 ± 3.952 a-c	135.253 ± 5.525 c	62.159 ± 2.807 a	128.956 ± 4 835 bc	693.247 ± 18.540 bc	0.522 ± 0.015 a	0.430 ± 0.011 a-c	0.545 ± 0.009 b

^AThe numbers given for each treatment represent the concentration expressed in mg L⁻¹