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Development and evaluation of an electromagnetic device to improve the physiological properties of some crop seeds

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Electronic supplementary material (ESM)

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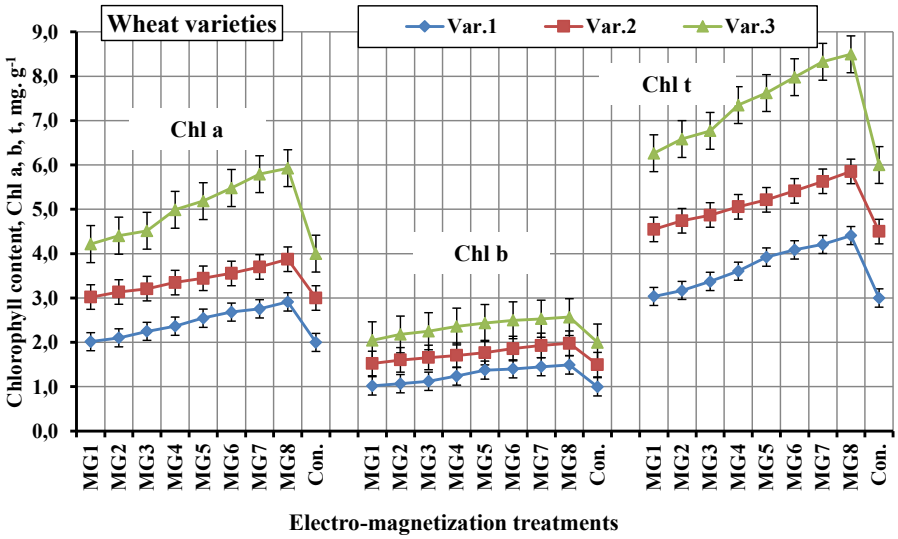
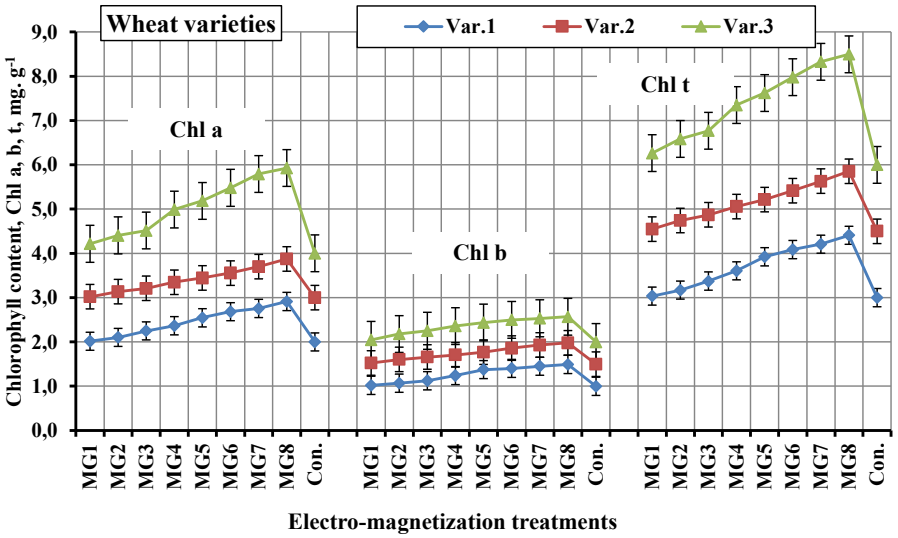
(A)



(B)



(C)

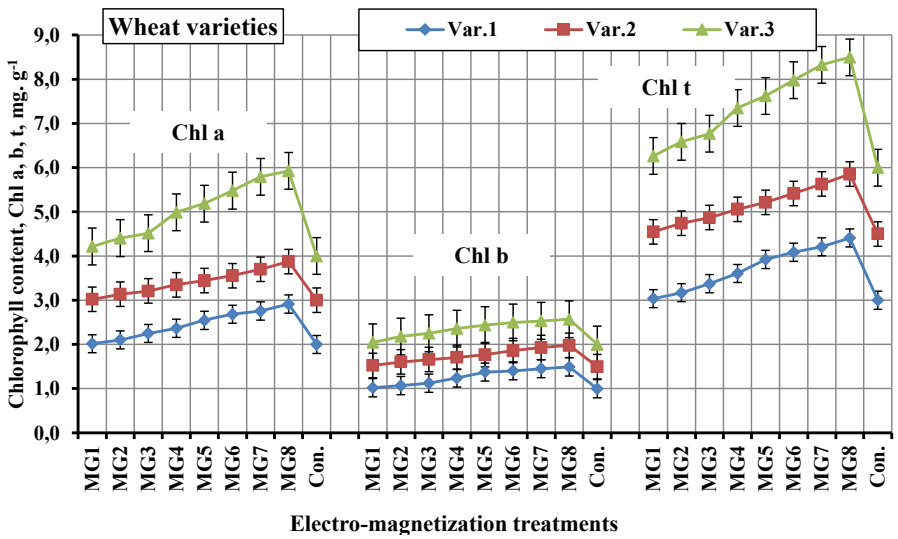


Figure S1. The effect of (A) electro-magnetization, (B) microwave radiation, and (C) both treatments on chlorophyll pigments of three wheat varieties: *Giza168, Gemmiz 9*, and *Sakha95*

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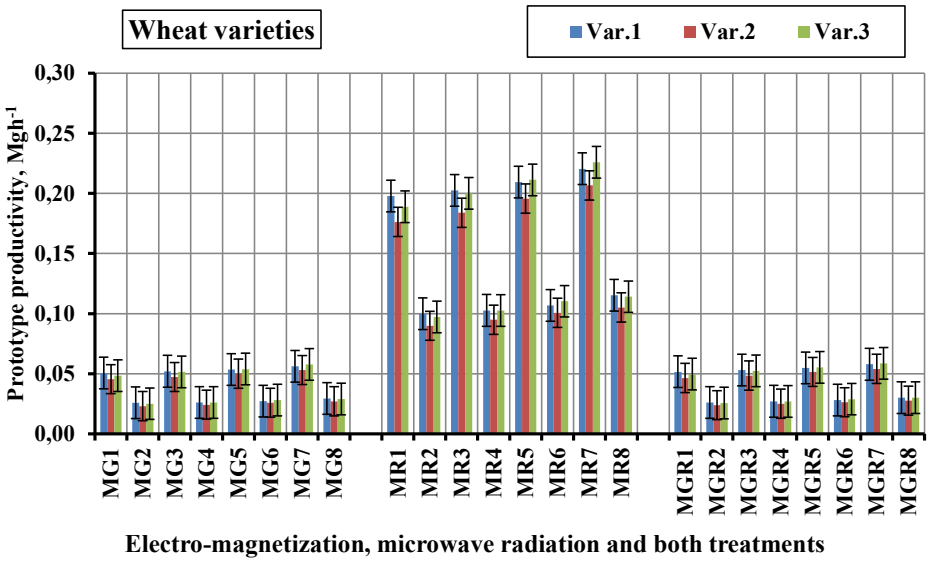
(A)



(B)

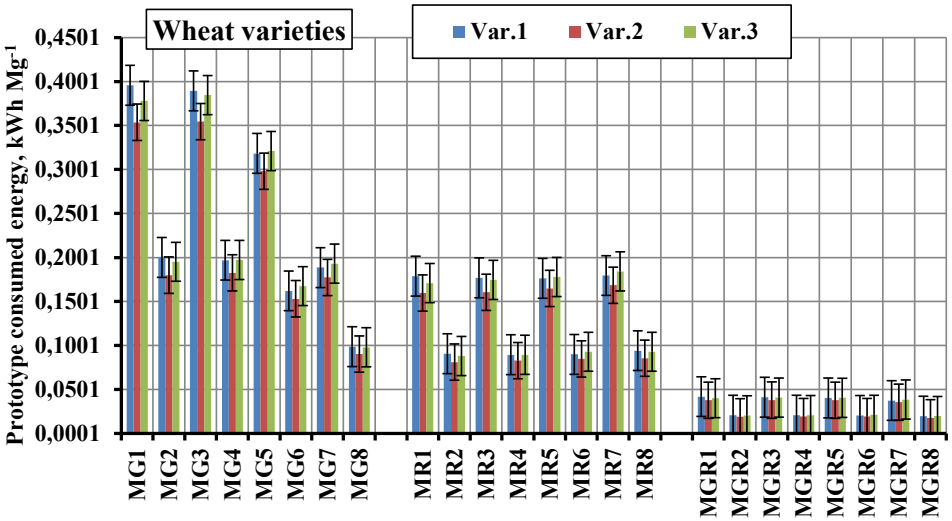


Figure S2. The effect of electro-magnetization, microwave radiation, and, both treatments on the prototype (A) productivity, and (B) consumed energy of three wheat varieties: *Giza168*, *Gemmiz 9*, and *Sakha95*

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Table S1. The specification of the electromagnetic seed stimulation device before sowing

Device dimensions	Length (mm)	Width (mm)	Height (mm)	Weight (kg)
	1 596	730	2 010	173
Power source	AC 220 V 50 HZ	consumed energy		up to 0.396 kWh·Mg^{-1}
Auger dimensions	length	screw pitch	outer diameter	shaft diameter
	1 200 mm	73 mm	120 mm	25 mm
Auger motor specifications	phase	power	voltage	ampere
	one phase	0.167 Hp	220 V	1.0 A
Seeds suction motor	rotation	air flow	voltage	power
	28 000 RPM	58 L·s^{-1}	230 V	1 200W
Device specifications	seeds type	capacity	productivity	maintenance
	wheat, rice, barley, etc.	5 kg·s^{-1}	Up to 2 tons per day	70 USD per year
Electro-magnet	type	MD-101AMR	magnet ranges	1.7–13.6 mT
DC power supply	power	350 W	output voltage	3.3, 5, and 12 V
Magnetron	type	Galanz M24FB	power	210 A
Microwave transformer	type	MD-801 EMR-1	voltage	230V 50 HZ
Microwave capacitor	type	CH85-2100 V AC	capacity	0.92 μF
Program timer	type	TM618N-2	range	20 A 30 VDC
DC voltmeter	voltage	4.5-24 V	current	0-10 A

Table S2. The statistical analysis values of the vegetative growth measurements

Treatments	Statistical values	*G*	*GI*	*GRI*	*MGT*	*CVG*	*Vi I*	*Vi II*	*Chl a*	*Chl b*	*Chl t*
MG	LSD (0.05)	0.575	0.946	0.97	0.0962	0.0828	31.628	0.632	0.0427	0.0141	0.0474
	P (MG.Var)	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***
	C.V	0.525	1.154	2.44	2.177	2.474	1.088	1.087	0.932	0.626	0.693
	R^2	0.896	0.8879	0.8219	0.8138	0.8689	0.8971	0.8971	0.8994	0.8996	0.8996
MR	LSD (0.05)	0.575	1.029	1.092	0.109	0.0868	118.758	2.375	0.043	0.014	0.048
	P (MR.Var)	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***
	C.V	0.538	1.284	2.747	2.472	2.723	4.517	4.517	1.09	0.848	0.849
	R^2	0.896	0.886	0.8081	0.8008	0.8617	0.8525	0.8525	0.8994	0.8996	0.8996
MGR	LSD (0.05)	0.571	0.964	0.936	0.0943	0.0849	32.762	0.655	0.0433	0.0142	0.0482
	P (MGR.Var)	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***
	C.V	0.51	1.158	2.393	2.1	2.388	1.024	1.024	0.829	0.495	0.595
	R^2	0.896	0.8875	0.8222	0.8114	0.8674	0.8971	0.8972	0.8994	0.8996	0.8996

***the significance probability value (*P*) is less than 0.001; *MG* – electro-magnetization treatments; *MR* – microwave radiation treatments; *MGR* – electro-magnetization and microwave radiation treatments; *G* – germination percentage (%); *GI* – germination index; *GRI* – germination rate index; *MGT* – mean germination time (day); *CVG* – germination velocity coefficient; *Vi I* – seed vigour index I; *Vi II* – vigour index II; *Chl a, b* & *t* – chlorophyll pigments, mg·g^{-1}; LSD – least significant differences; *P* – probability at level 99% ($P < 0.01$); C.V – variance coefficient; R^2 – determination coefficient

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Table S3. The regression analysis for the vegetative growth measurements

Treatments	values	*eq.= cons. + a* (*Var.*) + *b* (*T*)									
		G	*GI*	*GRI*	*MGT*	*CVG*	*Vi I*	*Vi II*	*Chl a*	*Chl b*	*Chl t*
	cons.	77.630	54.942	27.5290	3.8850	2.365	1777.790	35.555	0.267	0.388	0.655
MG	*a*	–0.123	–0.0359	0.0439	–0.0050	–0.011	–56.5980	–1.132	1.305	0.544	1.849
	b	2.135	2.295	0.8830	–0.0800	0.07	143.9060	2.878	0.170	0.071	0.241
	cons.	75.636	53.108	27.1140	3.9330	2.281	1611.0700	32.222	–0.240	-0.082	–0.322
MR	*a*	0.123	0.0766	0.1760	–0.0179	–0.0205	–45.5680	–0.911	1.310	0.544	1.854
	b	2.135	2.333	0.9210	–0.0860	0.0651	126.8170	2.536	0.171	0.071	0.242
	cons.	79.620	55.804	26.9640	3.9510	2.536	1983.2900	39.666	0.793	0.878	1.671
MGR	*a*	–0.098	0.054	0.1220	–0.0130	–0.016	–57.1820	–1.144	1.301	0.544	1.845
	b	2.124	2.284	0.8660	–0.0790	0.0718	149.8580	2.997	0.170	0.071	0.241

MG – electro-magnetization treatments; *MR* – microwave radiation treatments; *MGR* – electro-magnetization and microwave radiation treatments; *G* – germination percentage (%); *GI* – germination index; *GRI* – germination rate index; *MGT* – mean germination time (day); *CVG* – germination velocity coefficient; *T* – treatment; *Vi I* – seed vigour index I, *Vi II* – vigour index II; *Chl a, b* & *t* – chlorophyll pigments, mg g^{-1}; LSD – least significant differences