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Improving germination and quality of soybean seeds by using natural compounds

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ABSTRACT

Globally, soybean (*Glycine max* L.) is an important protein-and oil-rich crop. Farmers much attention to ordered high seed quality, which is associated with many important agronomical traits and can arise in a 30% increase in crop yields. By boosting germination, the seed coating technique increment yield, and seed quality. Moreover, seed coating is a desirable option as a tool for boost establishment of crops by speeding up difficulties that systems of agriculture face. The purpose of the experiment was to contrast the efficacy of seventeen natural compounds seed coating treatments namely (T1) Control seed without coating, (T2) Seed coated with arabic gum, (T3) Water only, (T4) Indole butyric acid IBA 100 ppm, (T5) Kaolin 6%, (T6) Glycine betaine 100 ppm, (T7) Sorbitol 1%, (T8) IBA+ Kaolin, (T9) IBA+GB, (T10) IBA+ Sorbitol, (T11) Kaolin + GB, (T12) Kaolin + Sorbitol, (T13) GB + Sorbitol, (T14) IBA + Kaolin + GB, (T15) IBA + GB + Sorbitol, (T16) Kaolin + GB + Sorbitol, (T17) IBA+ Kaolin + GB + Sorbitol. Results revealed that high chlorophyll content and crop growth rate were achieved when seed coating with T15 and T17. The tallest plants were recorded at T6 while T8 and T14 achieved the heaviest seed weight,100 seed weight, and number of pods per plant. T12 achieved a high number of seeds per plant. T8 recorded high seed yield per feddan, high germination percentage, and seedling dry weight, while T17 recorded the longest seedling length. T5 recorded high protein content and T15 achieved high carbohydrates and oil content. Thus, seed coating technologies enhance seed performance, and improve crop establishment, for sustainable agricultural systems. All seed-coating compounds are safe for both the environment and human health.

Keywords: Soybean; coating; kaolin; sorbitol; glycine betaine; indole butyric acid; seed quality; protein; oil content

INTRODUCTION

Soybean (*Glycine max* L.) is an essential crop globally. Soybean seeds have a cholesterol-free oil content of 18 to 22%, 85% unsaturated fatty acids, and 38 to 42% protein (Ali *et al.*, 2009; Awan *et al.*, 2023). Using high-quality seeds is one way to increase soybean production. Farmers always demand high-quality seed, which can increase crop yields by up to 30% (Afzal *et al.,* 2016). High-quality seed germination is necessary, but it does not ensure successful stand establishment. Sharma *et al.* (2015) pointed out that careful application of chemical, biochemical, and seed treatments can safeguard and improve implantation, growth, and potential productivity. One of the more sophisticated treatments is coating, which involves applying seeds with tightly adhering coatings of various chemical compositions. Zeng and Zhang (2010) and Jarecki (2022) using a coating on soybean seeds, it was possible to increase yield by 17.95% at a lower cost than using a commercial preparation. A type of auxin called indole-3-butyric acid (IBA) can be found in the tissues and plants of many different species naturally. IBA may be converted to IAA and vice versa, indicating that the two auxins' metabolisms are closely correlated Woodward & Bartel (2005). IBA exhibits the unique auxin potential of polar cell-to-cell transfer, though most likely via a different mechanism than IAA (Rashotte *et al.,* 2003). IBA has a much greater impact on initiation rooting than IAA and is more stable in solutions (Ludwig-Müller 2000; Davies, 2013). The naturally occurring chemical kaolin activates the intrinsic stress response in all crop plants and is a visible particle layer that reflects harmful UV and IR radiation (Hamdy *et al.,* 2022). When kaolin is applied to plants, a noticeable whitish film forms may be characterized as post-harvest practices that enhance seed germination, seedling growth, or the delivery of seeds and other materials needed at the time of sowing (Pedrini, 2018). One of the most compatible solutes, glycine betaine, plays a significant role in salinity by osmotic adjustment in plants (Ashraf and Harris 2004). Also, protecting the membrane structure, the cytoplasm and chloroplasts from Na+ damage, the photosynthetic mechanism, the proteins (by maintaining the structure of enzymes like Rubisco), and the oxygen radical scavenger Rahman *et al.* (2002). Sorbitol compound less inhibited seedling development, even stimulated plant development when added to the media at the lowest concentration it affected elongation of the root system, and increased the number of leaves and growth in the fresh and dry mass of plants (Kulpa *et al.,* 2018). The benefits of seed coating technologies include preserving seeds from pests and diseases at the time of planting and enhancing flow properties for precise seeding (Pedrini, 2018). Therefore, the purpose of the current study was to ascertain how soybean would respond to the seed application of protective coatings. Additionally, choosing low-cost, easily accessible coating agents is essential to the success of seed coating technology. For use in Egypt, a variety of low-cost, straightforward materials and techniques are required.

MATERIALS AND METHODS

A field experiments were carried out during two successive seasons at Tag Elzz Agric. Res. Stat., A.R.C., and the laboratory of seed technology research department, Dakahlia Governorate, Field Crops Research Institute, Agricultural Research Center, to determine its impact of natural compounds in improving germination and quality of soybean and crop performance on seed yield and quality of cultivar Giza 111 in clay soil. Randomize Complete Block Design (RCBD) were used in three replications for the subsequent seventeen treatments: i.e. T1. Control seed without coating T2. Seed coated with Arabic Gum T3. Water only T4. Indole butyric acid IBA 100 PPM T5. Kaolin 6% T6. Glycine betaine 100 ppm T7. Sorbitol 1% T8.IBA+Kaolin T9. IBA+GB T10.IBA+Sorbitol T11. Kaolin + GB T12. Kaolin + Sorbitol T13.GB + Sorbitol T14.IBA + Kaolin + GB T15.IBA + GB + Sorbitol T16. Kaolin + GB + Sorbitol T17. IBA+ Kaolin + GB + Sorbitol. Using a lab apparatus, the individual coating layers were prepared as solutions or emulsions and sprayed onto the seeds. Sixty seed were sown per 1 m^2. Row spacing was 50 cm and sowing depth was 4 cm. wheat was the preceding crop. The experiments were sown on May 15^{th} in the seasons of 2021 and 2022. Seeds were treated with Rhizobium japonicum before seeding.

Chlorophyll (a & b): were determined using fresh samples according to Sumanta *et al.* (2014). Accurately (0.5g) of fresh cutting parts was weighted and homogenized with 10 ml of methanol extracting solvent at 4°C in presence traces of sodium bicarbonate into the test tube covered by aluminum foil. Green color tincture concentration was spectrophotometric ally measured at (665.2nm) Chlorophyll and (652.4nm) Chlorophyll b wave length. The contents of total chlorophyll, chlorophyll a and chlorophyll b were calculated using the equations below:

Chlorophyll a = 16.72 X A665.2 - 9.16 X A652.4

Chlorophyll b = 34.09 X A652.4 - 15.28 X A665.2

As, A = Absorbance.

Chlorophyll content (mg/g fresh weight) = $\frac{\text{Chlorophyll content} \times \text{volume of methanol}}{1000 \times \text{weight of sample (g)}}$

Crop growth rate (CGR): using the following formula provided by **Watson (1952).**

Crop growth rate /week = W2 - W1/ (t2 - t1) *A

W1 and W2 dry weight at time (t1 and t2). A, ground area covered by plants (m^2).

Soybean was harvested when it reached full maturity at the technological maturity stage. Ten guarded plants had randomly sampled from each plot to measure the following parameters:

Plant height: was measured from the base of the plant to the top

Number of branches per plant: were measured at harvest

Number of pods per plant: were measured at harvest

Weight of seed per plant: were measured at harvest

100 seed weight: was counted, weight and recorded in gram

Seed yield per feddan Kg: were determined on plot basis. Seed yield was calculated per 1 feddan with consideration 15% moisture.

Germination percentage (G%): eight replications of 50 seeds of each treatment were planted and kept at 25 C° in an incubated chamber for eight days. Germination percentage was counted after eight days (I.S.T.A. 1999).

G % = number of normal seedling /number of seeds × 100

Seedling length (shoot and root length cm): ten normal seedlings eight days after planting then, the seedlings were dried in hot-air oven at 85 ^{0}C for12 hs.

Seedling dry weight (g): eight days after planting, ten seedlings were weighed in accordance with Krishnasamy and Seshu (1990).

Seed oil content: using Soxhlet apparatus and diethyl ether as a solvent.

Protein percentage: was determined based on A.O.A.C. (2000).

The data was statistically analyzed according to Gomez and Gomez (1984). Least Significant Difference (LSD) was used to compare treatment mean values at a 5% level of significance.

RESULTS

In order to increase soybean plants and seedling establishment while accelerating the difficulties that agricultural systems face, seed coating is a desirable option. Presowing seed treatment with promotion agents positively affected plant growth.

Data in Table 1 showed that seed coating treatments had an impact on the levels of the plant pigments chlorophyll a and chlorophyll b as well as on crop growth rate and plant height. The T15 and T16 recorded highest chlorophyll a (Chl a), while T17 recorded high chlorophyll b (Chl b) and crop growth rate. Regarding to plant height the T6 recorded highest plant height (95.3 and 98.3 cm) and T3 recorded the lowest values.

Table 1. Chlorophyll A, chlorophyll B, crop growth rate and plant height as influenced by natural compounds during 2021 and 2022 seasons.

Treatments	Chlorophyll A		Chlorophyll B		Crop growth rate		Plant height	
	2021	2022	2021	2022	2021	2022	2021	2022
T1	0.024	0.024	0.007	0.007	1.487	1.577	94.3	97.6
T2	0.025	0.039	0.011	0.011	0.453	0.503	72.7	76.6
T3	0.058	0.059	0.044	0.043	0.640	0.677	69.3	71.6
T4	0.057	0.057	0.072	0.071	0.573	0.600	74.3	76.6
T5	0.059	0.059	0.047	0.047	1.330	1.367	80.3	85.3
T6	0.055	0.055	0.089	0.089	1.633	1.663	95.3	98.3
T7	0.038	0.038	0.016	0.016	2.110	2.177	86.7	91.0
T8	0.056	0.056	0.053	0.052	1.420	1.497	78.3	83.3
T9	0.055	0.054	0.083	0.083	1.923	1.983	87.0	91.0
T10	0.044	0.043	0.021	0.021	1.560	1.610	81.7	87.3
T11	0.019	0.019	0.009	0.009	1.323	1.353	72.3	74.0
T12	0.056	0.056	0.020	0.020	1.213	1.270	86.6	90.6
T13	0.016	0.016	0.007	0.007	0.767	0.817	76.6	77.6
T14	0.053	0.053	0.024	0.024	1.170	1.217	80.6	85.6
T15	0.061	0.060	0.031	0.029	1.647	1.727	73.3	77.3
T16	0.058	0.058	0.071	0.071	1.650	1.680	83.3	88.0
T17	0.055	0.055	0.092	0.092	2.173	2.220	78.3	83.6
F test	**	**	**	**	**	**	**	**
LSD 0.05	1.012	1.01	1.11	1.233	0.0420	0.0436	4.3	3.9

The data in Table 2 indicate a significant impact on the traits under study, including weight of seed per plant, 100 seed weight, number of branches per plant, number of pods per plant, and number of seeds per plant. For the T8 treatments, the weight of seed/plant reached its highest means (30.27 and 30.49, respectively). The plant with the most seeds per unit was T12. However, every compound increases the number of seeds produced by a plant.

Table 2. Weight of seed/plant,100 seed weight, number of branches/plant, number of pods/plant, and number of seeds/plant as influenced by natural compounds during 2021 and 2022 seasons.

Treatments	Weight of seed/plant		100 seed weight g		Branches/plant		Pods/plant		Seeds/plant	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
T1	22.09	23.71	14. 23	14. 33	4.6	4.6	49	52	146	155
T2	25.92	27.67	15.14	15.35	3.3	3.0	48	50	143	150
T3	10.83	11.57	18.19	18.44	3.6	3.6	31	33	93	98
T4	17.65	19.26	11.70	11.77	4.0	4.3	51	55	153	165
T5	24.24	26.59	11.58	11.67	5.3	4.3	54	59	163	177
T6	10.22	10.79	14.92	15.03	4.6	4.0	25	26	76	79
T7	24.87	26.19	13.54	13.70	4.6	4.6	52	54	155	162
T8	30.27	30.49	16.04	16.15	6.0	5.6	79	80	166	166
T9	20.60	22.27	18.24	18.36	5.6	5.3	30	32	126	135
T10	24.57	26.47	16.29	16.53	5.0	4.6	77	80	130	140
T11	20.24	21.16	18.90	18.91	4.3	4.3	40	42	121	126
T12	28.28	29.35	16.79	16.82	5.0	4.6	60	63	181	187
T13	15.71	16.78	15.62	15.70	4.0	3.3	27	29	80	85
T14	20.10	21.00	19.63	19.74	5.3	5.0	35	37	105	109
T15	28.84	30.02	19.14	19.24	5.3	5.0	58	59	173	179
T16	20.23	21.98	16.72	16.83	4.6	4.6	47	50	140	150
T17	22.70	23.45	14.45	14.65	7.0	7.0	49	50	147	150
F test	**	**	**	**	NS	*	**	**	**	**
LSD 0.05	3.28	3.66	15.50	15.63	-	1.1	2.3	2.2	19.6	21.6

Data presented in Table 3 indicated that highly significant differences among seed agents were detected regarding studied characters i.e. seed yield Kg/fed, germination percentage, seedling length and seedling dry weight. T8 recorded highest seed yield (2119.0 and 2134.7) followed by T15 on the other hand the lowest values recorded at T4. High germination percentage recorded at T1, T8, T10, T11, T15 and T16 which lowest germination percentage when treated seed with water only at T3. The tallest seedling length recorded at T17. On the other hand, the lowest seedling length recorded at T1.

Table 3. Seed yield/feddan, germination percentage, seedling length and seedling dry weight as influenced by natural compounds during 2021 and 2022 seasons.

Treatments	Seed yield Kg/fed		Germination %		Seedling length cm		Seedling dry weight	
	2021	2022	2021	2022	2021	2022	2021	2022
T1	1546.7	1659.8	100	100	20.7	20.6	0.584	0.606
T2	1814.0	1936.6	80	84	20.3	21.8	0.734	0.758
T3	758.0	809.8	60	73	19.6	20.5	0.569	0.576
T4	1235.7	1347.9	70	77	19.8	21.9	0.560	0.557
T5	1696.7	1861.8	75	77	20.8	21.9	0.606	0.614
T6	715.3	755.8	75	79	23.3	24.3	0.580	0.589
T7	1740.7	1833.7	90	89	20.0	21.0	0.684	0.691
T8	2119.0	2134.7	100	100	21.6	22.9	0.874	0.880
T9	1442.0	1559.2	93	100	22.0	22.9	0.711	0.717
T10	1720.0	1853.2	100	100	22.9	23.2	0.840	0.842
T11	1416.7	1481.2	100	100	22.0	22.2	0.771	0.779
T12	1979.7	2054.7	90	100	22.0	22.8	0.772	0.780
T13	1099.3	1174.6	97	100	26.0	27.1	0.868	0.866
T14	1407.3	1470.0	90	100	24.7	26.4	0.651	0.678
T15	2018.7	2101.4	100	100	26.0	27.6	0.771	0.789
T16	1416.0	1538.6	100	100	26.0	27.2	0.802	0.808
T17	1589.3	1641.2	93	100	26.3	27.9	0.747	0.754
F test	**	**	**	**	**	**	**	**
LSD 0.05	229.86	256.20	9.9	6.1	2.033	2.164	0.052	0.061

With respect to seed quality, the data in **Table (4)** revealed that protein percentages, carbohydrate and oil percentage have significant response in treatments in the two seasons. So, it can be noted that T15 had the higher values of protein content (34.13 and 34.18), carbohydrate (23.94 and 24.00) and oil percentage (24.52 and 24.58), respectively.

Table 4. Seed protein, carbohydrates percentage and oil percentage as influenced by compounds in both seasons.

Treatments	Seed protein		Carbohydrates		Oil content	
	2021	2022	2021	2022	2021	2022
T1	33.04	33.05	22.12	22.16	23.43	23.45
T2	33.02	33.04	22.00	22.03	23.22	23.32
T3	33.98	33.99	23.40	23.49	24.23	24.29
T4	33.85	33.87	23.06	23.10	24.12	24.15
T5	34.04	34.05	23.57	23.61	24.35	24.15
T6	33.46	33.50	22.93	22.99	23.92	23.97
T7	33.00	33.02	22.44	22.50	23.02	23.06
T8	33.64	33.68	23.01	23.07	24.01	24.03
T9	33.42	33.48	22.90	22.98	23.83	23.93
T10	33.15	33.20	22.58	22.62	23.52	23.58
T11	33.02	33.06	21.90	22.00	23.13	23.18
T12	33.54	33.60	22.96	23.00	23.93	23.98
T13	32.98	33.01	21.51	21.59	24.15	24.18
T14	33.13	33.18	22.73	22.79	23.64	23.69
T15	34.13	34.18	23.94	24.00	24.52	24.58
T16	33.95	34.00	23.26	23.35	24.23	24.29
T17	33.36	33.41	22.82	22.85	23.75	23.79
F test	**	**	**	**	**	**
LSD 0.05	0.043	0.032	0.036	0.037	0.037	0.043

DISCUSSION

Kaolin, glycine betaine, sorbitol, and indole-3-butyric acid are all organic compounds that aid in the growth and development of plants. Numerous plant developmental processes, such as cell division, the initiation of roots and vascular tissues, bud and flower development, are regulated by synthetic or natural substances (Davies, 2013). On growth and seed quality, the impact of coated and foliar applications of indole-3-butyric acid (IBA) was examined. With a decline in lignin levels and a corresponding drop-in peroxidase activity, the hypocotyls of cuttings treated with IBA produced noticeably more adventitious roots. IBA application was able to cause the internodes to lengthen, promoting the growth of the pea plants' stems Yang & Davies (1999). Additionally, IBA application increased the leaf area and dry weight of chickpea leaves Amin *et al.* (2013). As a result, the rise in shoot fresh weight following IBA treatment may be attributable to increases in shoot length, leaf area, and leaf fresh weight. These results are consistent with previous studies which observed that the application of IBA promoted plant and shoot length, plant height, and dry weight of both branches and leaves (Umadi *et al.,* 2018). The findings of the current study demonstrated that IBA treatment increased the length, weight, and number of shoots on soybean plants. In contrast, there was no discernible difference between the IBA treatment group and the control group in terms of the number of petioles. This increase may be attributed to the role of auxin in stimulating cell division and elongation (Davies, 2013). The kaolin application at 6% coincided with the cell expansion stage Hamdy *et al.* (2022). Soybean has high nutritional values and is one of the most important protein-and oil-rich crops grown throughout the world. Consumption of soybean seeds has increased because of the food industry's rapid growth (Que *et al*., 2019). In the current study, different compounds of indole 3 butyric acid, kaolin, glycine betaine, and sorbitol were applied to soybean seed to study their effects on soybean yield and seed quality. Sorbitol has the effect of promoting nutrient absorption, so it has the potential to produce excellent fertilizers.

CONCLUSION

Generally, data obtained through this work show that treatments of kaolin, glycine betaine, sorbitol, and indole 3 butyric acid Implementation significantly enhanced the growth parameters. Sorbitol and glycine betaine were the next tested compounds, with kaolin providing the best results across all parameters in both the lab and the field at all growth phases. All seed coating components are natural and safe for the environment and human health. In light of this, we advise using T15 and T17 to enhance soybean seeds.

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تحسين انبات وجودة بذور فول الصويا باستخدام المركبات الطبيعية

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ان تقنية تغليف البذور تعمل على تحسين مراحل الإنبات وتحسين جودة بذور فول الصويا. بالإضافة إلى ذلك ، يوفر تغليف البذور خيارًا كأداة لتحسين جودة المحاصيل. لذلك اقيمت تجربتين حقليتين بمحطة البحوث الزراعية بتاج العز ومعمل وحدة بحوث تكنولوجيا البذور بالمنصورة خلال موسمي 2021 و 2022 لتقيم سبعة عشر معاملة لتغليف بذور فول الصويا صنف جيزة 111 وكانت المعاملات هي :

1 -المعاملة الكنترول بدون تغليف 2- التغليف بالصمغ العربي فقط 3-المعاملة بالماء فقط 4- التغليف باندول بيوترك اسد 100 جزء في المليون

-5 التغليف بمادة الكاولينا بتركيز 6% 6- التغليف بالجليسين بيتين بتركيز 100 جزء في المليون 7-التغليف بالسوربيتول بتركيز 1%

-8 التغليف باندول بيوترك اسد + الكاولينا 9- التغليف باندول بيوترك اسد + الجليسين بيتين 10-التغليف باندول بيوترك اسد + السوربيتول

-11 التغليف بالكاولينا + الجليسين بيتين 12-التغليف بالكاولينا + سوربيتول 13-التغليفب بالجليسين بيتين + السوربيتول

-14 التغليف باندول بيوترك اسد + الكاولينا + جليسين بيتين 15- التغليف باندول بيوترك اسد + الجليسين بيتين + السوربيتول

-16 التغليف بالكاولينا + الجليسين بيتين + السوربيتول 17- التغليف باندول بيوترك اسد + الكاولينا + الجليسين بيتين + السوربيتول .

كانت أهم النتائج المتحصل عليها كالتالي:أوضحت النتائج ارتفاع نسبة الكلوروفيل وإنتاجية المحصول تم تحقيقها عند تغليف البذور بالمعاملة T15 و . T17 تم تسجيل أطول نباتات عند T6 بينما حقق T8 و T14 أثقل وزن بذرة وعدد القرون لكل نبات. حققت المعاملة T12 عددًا كبيرًا من البذور لكل نبات بينما سجلت المعاملة T8 اعلي محصول بذور للفدان ، ونسبة إنبات ، ووزن جاف للبادرة ، بينما سجل T17 اكبر طول نبات. سجلت T5 اعلي نسبة بروتين وحققت T15 نسبة عالية من الكربوهيدرات والزيوت. وبالتالي ، فإن تقنيات تغليف البذور تعزز أداء البذور، وتحسن نمو المحاصيل للنظم الزراعية المستدامة.

الكلمات المفتاحيه:فول الصويا، التغليف ،الكاولين ،السوربيتول ،الجلايسين البيتين، حمض الإندول بيوترك، جودة البذور ،البروتين ،محتوى الزيت