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Mini Review

Seed Priming, A Re-Discovered Old Method

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Rapid and uniform seedling emergence is a basic requirement for crop production, especially under adverse environmental conditions. Techniques that favourably influence the germination and growth of plants have a direct impact on final yield as the treated plants are more robust and resistant to biotic or abiotic stress factors [1]. The easiest way to do this is to sort the seeds and discard those that are too small and possibly damaged. There are two basic groups of actual seed treatment: dressing and soaking. Dressing is the treatment of a seed using chemical substances, the active ingredient of which do not enter the seed. The purpose of this process is to destroy pathogenic substances on the surface of seeds or in the soil. In contrast to this, soaking is a method of seed treatment that stimulates growing, thus reducing germination time and making it more uniform.

The potentials and benefits of seed soaking were discovered in Ancient Times, and were not forgotten even in the Middle Ages. As the first soaking technique, the sap of onion cypress was used in Egypt, Greece and the Roman Empire, while in the Middle Ages soaking in chlorine salt and manure was applied [2]. However, its re-discovery from the 1960s has become more intense in the last 10 years [3]. There are three basic ways of soaking: clean water soaking, soaking in a wet solid matrix, and soaking in a solution having a lower osmotic potential than clean water, viz. a solution with negative osmotic potential [4]. During priming, water is taken up by the seed, which swells, and the germination process begins. Germination itself can be divided into three phases. The first phase involves the hydration of the core, while in the second phase metabolic changes and repair mechanisms are activated, and then in the third phase growth processes begin [5]. Knowledge of these phases is important since germination is irreversible from the end of the second phase. If soaking is ceased before the end of the second phase, it is possible to regenerate and store the seeds before sowing so that the beneficial effects prevail, but without the sprouts being damaged if sowing is delayed.

Obviously, the efficiency of priming is influenced by a number of factors such as ventilation, light, temperature, time and seed quality. As a general rule, soaking cannot take longer than 6 to 12 hours, because if a germ cannot get oxygen for a long time, the cells will be damaged, accordingly air supply is necessary. It is also important to check the amount of water taken up in order to achieve an equal level of hydration in the seeds. The development of the drum procedure resulted in a more uniform water absorption. Wet organic or inorganic matrices such as charcoal or sand make it possible to slow down the water uptake of seeds. When using osmotics, however, it should be take into consideration that while polyethylene glycol is not able to enter the seed because of its size, the accumulation of inorganic salts such as NaCl, KCl or $MnSO_4$ in the seed may be toxic. Also, certain seeds require light or suitable temperature for germination. When soaking is completed, special care must be taken with regard to drying which must be gentle and slow [6]. In addition, it is important to understand that all priming processes and steps need to be optimized for the given plant species.

Although seed soaking is a long-known technique, the underlying physiological and biochemical processes are less understood. Research results show that the positive effect of priming on the germination performance of many species is related to the induction of repair mechanisms. Although priming itself does not have a direct effect on cell division, but advances it in the third phase of germination, it has a role in promoting the essential enhancement of the DNA before cell division, contributing to the healthy development of the embryo [4]. In the course of the soaking process, the synthesis of proteins required for the germination takes place, the appearance of which may take longer time without priming. In addition, soaking also contributes to strengthening the antioxidant defence system [3].

Despite its many advantages, seed soaking has not yet spread widely, and is mainly used in horticulture and vegetable production. However, numerous scientific results have emerged recently in support of further potential applications in addition to the three so-called soaking methods. Attention is currently focused on useful secondary effects of fungicides on seedling development, as some originally broad-spectrum seed-applied fungicides have some potential biostimulant activities, and may be beneficial in overcoming biotic and abiotic stresses in early growth stages [7]. An interesting new method is the so-called biopriming, when the seed is coated with a bacterium or fungus to protect the seed from a pathogen [8,9]. As the replacement of synthetic chemicals is a much more urgent need, the use of naturally occurring biologically active compounds can be an alternative to improving plant yields. Plant enhancers (biostimulants) e.g., plant hormones such as salicylic acid - found in the bark of the willow and used in folk medicine for pain and fever – have been reported to be effective as a seed priming compound, and increased seed germination and seedling vigour [10,11]. Polyamines, the plant growth promoting molecules, which are found in all living cells, were also found to be effective when applied as a seed soaking treatment in stimulating early plant growth and providing protection against cadmium stress [6,12,13]. Likewise, the beneficial effect of the antioxidant ascorbic acid has also been described [14]. Even better results can without doubt be achieved when these protective compounds are used in combination, as in the case of a few foliar fertilizers. However, while we can find more and more foliar-applied products on the market, including an increasing number of plant extracts, we can only find a few descriptions where they are recommended to be also used as a seed priming agent [15,16].

According to recent research results, such and similar protective compounds (plant hormones, antioxidant, etc.), upon application at a suitable concentration, are taken up by the seeds and accumulate in the seedlings without any negative side effects [17,18]. Indeed, these treatments such as a mild stress have effects on the plants, and - similarly to the training process - activate gene expression and the synthesis of further protective compounds, which may result in increased resistance. Under unfavourable environmental conditions, these protective compounds naturally accumulate in plants as part of the plant stress responses, but their beneficial effects are not manifested in time so plant growth inhibition can occur.

Our age is full of smart products, and there is no reason why a seed treatment method could not be smart as well. According to a recent study, it is possible to increase the chilling tolerance of maize seeds. The essence of the method is that the seeds are coated with a thermosensitive hydrogel containing salicylic acid, the plant hormone already mentioned. At a temperature below 12°C, when maize is exposed to low temperature stress, salicylic acid is released from the hydrogel and its effect on the seed results in higher germination rates and the length and weight of young shoots and roots are higher than those of untreated ones [19].

To summarise, the use of naturally occurring compounds as seed priming agent to synchronise the metabolic events during germination and enhance/unify emergence and also to improve plant tolerance to multiple abiotic stresses is highly promising. According to these studies, it is required to optimize the recommended application range and to develop more useful combinations of treatments for practical use, and to reveal the physiological background of the beneficial effects at molecular and gene expression levels.

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