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A Moharana
Department of Seed Science and Technology, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

S Mohanty
Department of Seed Science and Technology, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

D Lenka
Department of Seed Science and Technology, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

RK Nayak
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

SN Jena
Department of Agronomy, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

M Satapathy
Department of Agronomy, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

GBN Jyothi
Department of Seed Science and Technology, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

Corresponding Author:
A Moharana
Department of Seed Science and Technology, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

Effect of seed priming and coating with boron and molybdenum on seed physiological quality and seed yield of groundnut (*Arachis hypogaea* L.)

A Moharana, S Mohanty, D Lenka, RK Nayak, SN Jena, M Satapathy and GBN Jyothi

Abstract
Seed priming and coating are considered as important seed quality enhancement techniques that result in early establishment of crop seedling. Thus, the effect of seed priming and coating with different doses of boron (B) and molybdenum (Mo) on growth, physiological quality and yield components of groundnut (cv. ICGV-91114) was evaluated. The experiment was taken in RBD having 21 treatments and three replications. The crop was grown in *Rabi* season of 2018-19 and 2019-20 at the Experimental Farm of OUAT, Bhubaneswar. Data revealed that seed germination and seed vigor index-I were highest in treatment T_{17} (T_2 + T_{10}), i.e., 0.5 g/l borax solution + 0.5 g/l sodium molybdate solution. Similarly, all measured yield attributing parameters i.e., pod yield per plant (g) and kernel yield per plant (g) were Significantly higher at treatmentT_{17} (T_2 + T_{10}) as compared to the other treatment combinations and control. The control plot resulted in the lowest values for all the parameters studied. It can be concluded that seed priming with 0.5 g/l borax solution + 0.5 g/l sodium molybdate solution can be used for obtaining higher seed yield of groundnut.

Keywords: seed priming, seed coating, boron, molybdenum, groundnut, yield, germination, vigor

Introduction
Groundnut (*Arachis hypogaea* L.) is an economically important oilseed crop also called as peanut or monkey nut. It is the 13th important food crop in the world and first crucial oilseed crop in India. It is a major source of edible oil and vegetable protein hence it is often known as King of oilseeds. Groundnut is an excellent plant-based source of protein (25-36%) and vegetable oil (47-53%) (Jeyaraman, 2017) [14]. In India, groundnut is grown in 11 states, accounts for 27 percent of total production of oilseed. Oilseed occupies an important position in Indian economy by contributing about 4% Gross National Product (GNP). At the present level area and production, it occupies about 6.09 million hectares, 10.21 million tonnes and productivity is about 1.67 t/ha in India (DAC, 2021) [22]. Micronutrient insufficiency is one of the main reasons for the low yield of groundnuts. Intensification of agriculture, usage of straight fertilizers, rising crop requirements due to increasing productivity levels have increased the micronutrients demand in soil fertility management and are increasingly becoming major constraints to achieve agricultural production. Nutri-priming technique is considered to be an efficient way from economic point of view as it uses low doses of micronutrients and is easy to operate. It also facilitates the vigorous germination and seedling emergence, better stand establishment and crop growth (Singh, 2003) [20]. Micronutrient boron and molybdenum are very much vital for growth, yield of groundnut crop. Boron is the next important micronutrient after Zn required by the plant for their growth and development. Boron has the ability to increase photosynthetic and enzymatic activity in plant; moreover, it causes pollen grain germination, pollen tube growth and viability of pollen grains (Dugger, 1973) [21]. Molybdenum plays a significant role in various enzymatic and physiological activities of plants with obvious role in nitrogen fixation through root nodules in leguminous crops. In crop plants, seed invigoration is a broader term and has been used in two different ways, *i.e.*, seed priming and seed coating (Farooq *et al*., 2009) [15]. Seed priming improves the germination speed (Deering and Young, 2006) [16], minimizes the time between sowing and emergence, enhances seedling emergence and vigor, crop establishment and uplift yield (Ali *et al*., 2007, Arif *et al*., 2005, Diniz *et al*., 2009) [17, 18, 19].

In the light of the importance of micro-nutrients, the main objective of the present study was to evaluate the effects of seed priming and coating with micronutrients i.e., boron and molybdenum on the seed physiological and yield attributing parameters of groundnut.

Materials and Methods

The study was carried out to determine the effects of seed priming and coating with B and Mo on the seed physiological and yield attributing parameters of groundnut during *Rabi* season of 2018-19 and 2019-20 at Experimental Farm, OUAT, Bhubaneswar. The climate of the region is tropical throughout the cropping duration and soil of the farm is loamy sand in texture with pH of 5.42. An approved variety of groundnut (cv. ICGV-91114) was used. The seeds were sown in line at a depth of 2-3 cm with spacing of 45 x 15 cm. The experiment was laid out in Randomized Block Design and replicated three times. After initial germination test, the seeds were subjected to various seed priming and coating treatments using borax and sodium molybdate as the sources of the micronutrients, boron and molybdenum. After priming and coating procedures, seeds were dried back to original moisture content, followed by germination tests. The treated seeds were sown in the field to study their field performance. The seed physiological quality and seed yield were studied.

Seed germination

$$\text{Seed germination (\%)} = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds put for germination}} \times 100$$

Seed vigour index-I

Seed vigour index-I was calculated by adopting the method expressed by Abdul Baki and Anderson, (1973) and expressed as whole number.

Seed vigour index-I = Germination (%) x Mean seedling length (cm)

Pod yield per plant

The selected plants from each plot were harvested and dried for 2 days in sun, followed by stripping to separate the pods. The pods were then dried to seed moisture content below 8%. The weight of pods from these selected plants of each plot was taken, the mean pod yield per plant calculated and expressed in grams.

Kernel yield per plant

The pods used for recording observation on pod yield per plant were decorticated and the weight of kernels taken. The mean kernel yield per plant was calculated and expressed in grams.

Results

Seed germination

The impact of seed priming, seed coating, soil and foliar application of micronutrients on the plant was investigated. In the present investigation, freshly harvested seed from a crop grown from primed, coated, soil and foliar-applied harvested seeds was used to investigate germination. The results are presented for both *Rabi* 2018-19 and *Rabi* 2019-20. Table 1 displays the pooled mean data along with their converted values. In general, seed priming with borax solution or sodium molybdate solution resulted higher germination than seed coating, foliar spray and soil application. Seed priming with 0.5 g/l borax solution and 0.5 g/l sodium molybdate solution (T_{17}) resulted in the highest germination rate of 90.33 percent, followed by seed priming with 1 g/l borax solution (T_3), i.e. 88.75 percent. T_{17} was significantly superior over all other treatments except T_3. Untreated Control showed the lowest germination i.e., 75.50%. Among the treatments, seed priming with 0.5 g/l borax solution + 0.5 g/l sodium molybdate solution (T_{17}) showed the greatest percent increase over the Control, which was 19.6%, followed by seed priming with 1 g/l borax solution (Fig 1A).

Seed vigour index-I

The impact of seed priming, seed coating, soil and foliar application of micronutrients on the plant was investigated. It was computed as the product of germination rate and seedling dry weight for both growing seasons. Table 1 displays the pooled mean data. In general, seed priming with borax solution or sodium molybdate solution resulted in more seed vigour than seed coating, foliar spray and soil application. Seed priming with 0.5 g/l borax solution + 0.5 g/l sodium molybdate solution (T_{17}) resulted in the highest vigour of 1551.0, followed by seed priming with 1 g/l borax solution (T_3), i.e., 1501.2. T_{17} was significantly superior over all other treatments except T_3. The untreated Control showed the lowest seed vigour index of 1063.80 (T_{21}). Among the treatments, seed priming with 0.5 g/l borax solution + 0.5 g/l sodium molybdate solution (T_{17}) showed the highest percent increase over the control, which was 45.8%. This was followed by seed priming with 1 g/l and the value was 41.1% (Fig 1B).

Pod yield per plant (g)

The impact of seed priming, seed coating, soil and foliar application of micronutrients on the plant was investigated for both growing seasons, *Rabi* 2018-19 and Rabi 2019-20 and the pod yield of each plant was reported. The pooled mean values are shown in Table 2. In general, seed priming with borax solution or sodium molybdate solution resulted in a better pod production per plant than seed coating, foliar spray and soil application. Seed priming with 0.5 g/l borax solution and 0.5 g/l sodium molybdate solution (T_{17}) produced the highest pod yield per plant of 14.49 g, followed by seed priming with 1 g/l borax solution (T_3), i.e., 14.13 g. T_{17} was significantly superior over all other treatments except T_1, T_2, and T_3. The untreated Control had the lowest pod yield per plant (10.65 g) (T_{21}). Among the treatments, seed priming with 0.5 g/l borax solution + 0.5 g/l sodium molybdate solution (T_{17}) recorded highest percent increase over Control which was 36.02%, followed by seed priming with 1 g/l borax solution and the value was 32.65%(Fig 2A).

Kernel yield per plant (g)

The impact of seed priming, seed coating, soil and foliar application of micronutrients on the plant was investigated for both *Rabi* 2018-19 and *Rabi* 2019-20 and the number of kernels produced by each plant was documented. The pooled mean values are shown in Table 2. In general, seed priming with borax solution or sodium molybdate solution resulted in a better kernel production per plant than seed coating, foliar spray and soil application. Seed priming with 0.5 g/l borax solution + 0.5 g/l sodium molybdate solution (T_{17}) produced the highest kernel yield per plant, 10.29 g, followed by seed priming with 1 g/l borax solution (T_3), which produced 10.17 g. T_{17} was significantly superior over all other treatments except T_1, T_2, and T_3. The untreated Control showed the lowest kernel yield per plant (7.59 g) (T_{21}).

Discussion

The percentage of germination is the basic physiological criteria used to evaluate the planting value of seed. In comparison to seed coating, foliar spray and soil application, seed priming treatment with borax solution and sodium molybdate solution resulted in better germination (%). Seed priming with 0.5 g/l borax solution and 0.5 g/l sodium molybdate solution (T_{17}) resulted in the highest germination rate of 90.33 percent, followed by seed priming with 1 g/l borax solution (T_3), i.e., 88.75 percent. The outcome can be attributed to the favourable environmental circumstances prevalent throughout seed growth stage. Variation in germination of seeds produced are also documented by Gasper *et al*. (1980) [2] in maize, Banumurthy and Gupta (1981) [1] in soybean, Vanangamudi and Kulandaivelu (1989) [3] in sorghum.

Among the treatments, seed priming with 0.5 g/l borax solution + 0.5 g/l sodium molybdate solution (T_{17}) gave better seed vigour index-I of 1551.0 followed by seed priming with 1 g/l borax solution (T_3), 1501.2. T_{17} was significantly superior over all other treatments except T_3. The untreated Control showed the lowest seed vigour index of 1063.80 (T_{21}). (Copeland, 1988) [4] revealed that Bagalkot produced seeds recorded greatest vigour index (2699) than Dharwad (2460) and Chitradurga produced seeds (2165). The increased root and shoot length, germination rate, and seed weight per 100 seeds could account for the seeds' maximum seedling vigour index. Vanangamudi and Kulandaivelu (1989) [3] have reported such variation in seedling vigour index in sorghum.

The increased pod yield of groundnut due to the treatment of boron and molybdenum may be attributed to improved crop stand and increases in plant height, number of pods per plant, and test weight as a result of enhanced root growth and nodulation. Similar findings were reported by Singh *et al*. (1990) [5], Sahu *et al*. (1995) [6], Bhuiyan *et al*. (1997) [7], Noor *et al*. (1997) [8] and Shankhe *et al*. (2004) [9]. Boron is necessary for cell differentiation, development and pollen grain expansion. Borate ion forms complex with numerous polyhydroxy and related substances. It assists in transport of growth regulators within the plant and helps in polymerization of phenolic compounds (Tandon, 1995) [10]. Molybdenum is vital for N_2-fixation, which has assured greater N supply to the crop and activation of enzyme nitrate reductase, a soluble molybdoflavoprotein in plant (Tandon, 1995) [10], leading to increased crop growth and production. De and Chatterjee also reported identical results (1976) [11]. As the soil was initially deficient in B, the soils must be in greater need of B due to the continuous groundnut cropping; therefore, timely application of B as soil and foliar application would increase the yield attributes, possibly through the process of tissue differentiation from somatic to reproductive, meristematic activity.

The highest kernel production per plant was obtained for the T_{17} (T_2 + T_{10}) treatment. This kernel yield result is consistent with the findings of Mohapatra and Dixit (2010) [12]. Murthy (2006) [13] observed that the application of B increased the seed production of sesame, linseed, mustard, sunflower, and groundnut by 90, 150, 210, 320, and 370 kg/ha, respectively.

Table 1: Effect of seed priming and coating with borax and sodium molybdate on germination and seed vigour index-I of harvested seeds of groundnut cv. ICGV 91114

Treatments	Seed germination (%)*	Seed vigour index-I
T_1: Priming with borax 0.1 g/l	87.67 (9.36)	1479.1
T_2: Priming with borax 0.5 g/l	88.17 (9.39)	1488.3
T_3: Priming with borax 1.0 g/l	88.75 (9.42)	1501.2
T_4: Coating with borax 100 mg/kg seed	82.75 (9.10)	1255.1
T_5: Coating with borax 200 mg/kg seed	81.83 (9.05)	1229.6
T_6: Coating with borax 300 mg/kg seed	81.25 (9.01)	1215.8
T_7: Two foliar sprays of borax 100 ppm	79.50 (8.92)	1154.8
T_8: Soil application of borax 10 kg/ha	84.58 (9.20)	1339.4
T_9: Priming with SM 0.25 g/l	85.58 (9.25)	1400.0
T_{10}: Priming with SM 0.50 g/l	86.75 (9.31)	1434.4
T_{11}: Priming with SM 0.75 g/l	86.33 (9.29)	1416.1
T_{12}: Coating with SM 2 g/kg seed	79.33 (8.91)	1143.8
T_{13}: Coating with SM 4 g/kg seed	79.08 (8.89)	1134.5
T_{14}: Coating with SM 6 g/kg seed	78.67 (8.87)	1121.4
T_{15}: Two foliar sprays of SM 50 ppm	78.00 (8.83)	1098.2
T_{16}: Soil application of SM 1.5 kg/ha	83.92 (9.16)	1311.7
T_{17}: T_2 + T_{10}	90.33 (9.50)	1551.0
T_{18}: T_5 + T_{13}	83.17 (9.12)	1288.4
T_{19}: T_7 + T_{15}	80.17 (8.95)	1181.9
T_{20}: T_8 + T_{16}	85.08 (9.22)	1371.1
T_{21}: CONTROL	75.50 (8.69)	1063.8
Mean	83.16 (9.12)	1294.26
S.Em(±)	0.031	20.12
$CD_{0.05}$	0.087	56.5

Table 2: Effect of seed priming and coating with borax and sodium molybdate on pod yield per plant and kernel yield per plant in groundnut cv. ICGV 91114

Treatments	Pod yield per plant (g)	Kernel yield per plant (g)
T_1: Priming with borax 0.1 g/l	14.02	10.01
T_2: Priming with borax 0.5 g/l	14.08	10.04
T_3: Priming with borax 1.0 g/l	14.13	10.17
T_4: Coating with borax 100 mg/kg seed	12.59	8.91
T_5: Coating with borax 200 mg/kg seed	12.51	8.62
T_6: Coating with borax 300 mg/kg seed	12.05	8.61
T_7: Two foliar sprays of borax 100 ppm	11.90	8.23
T_8: Soil application of borax 10 kg/ha	13.23	9.08
T_9: Priming with SM 0.25 g/l	13.62	9.32
T_{10}: Priming with SM 0.50 g/l	13.91	9.55
T_{11}: Priming with SM 0.75 g/l	13.81	9.39
T_{12}: Coating with SM 2 g/kg seed	11.71	8.02
T_{13}: Coating with SM 4 g/kg seed	11.21	7.96
T_{14}: Coating with SM 6 g/kg seed	11.03	7.82
T_{15}: Two foliar sprays of SM 50 ppm	11.02	7.81
T_{16}: Soil application of SM 1.5 kg/ha	12.82	9.07
T_{17}: T_2 + T_{10}	14.49	10.29
T_{18}: T_5 + T_{13}	12.69	9.04
T_{19}: T_7 + T_{15}	12.01	8.30
T_{20}: T_8 + T_{16}	13.28	9.15
T_{21}: CONTROL	10.65	7.59
Mean	12.70	8.90
S.Em(±)	0.193	0.152
$CD_{0.05}$	0.541	0.426

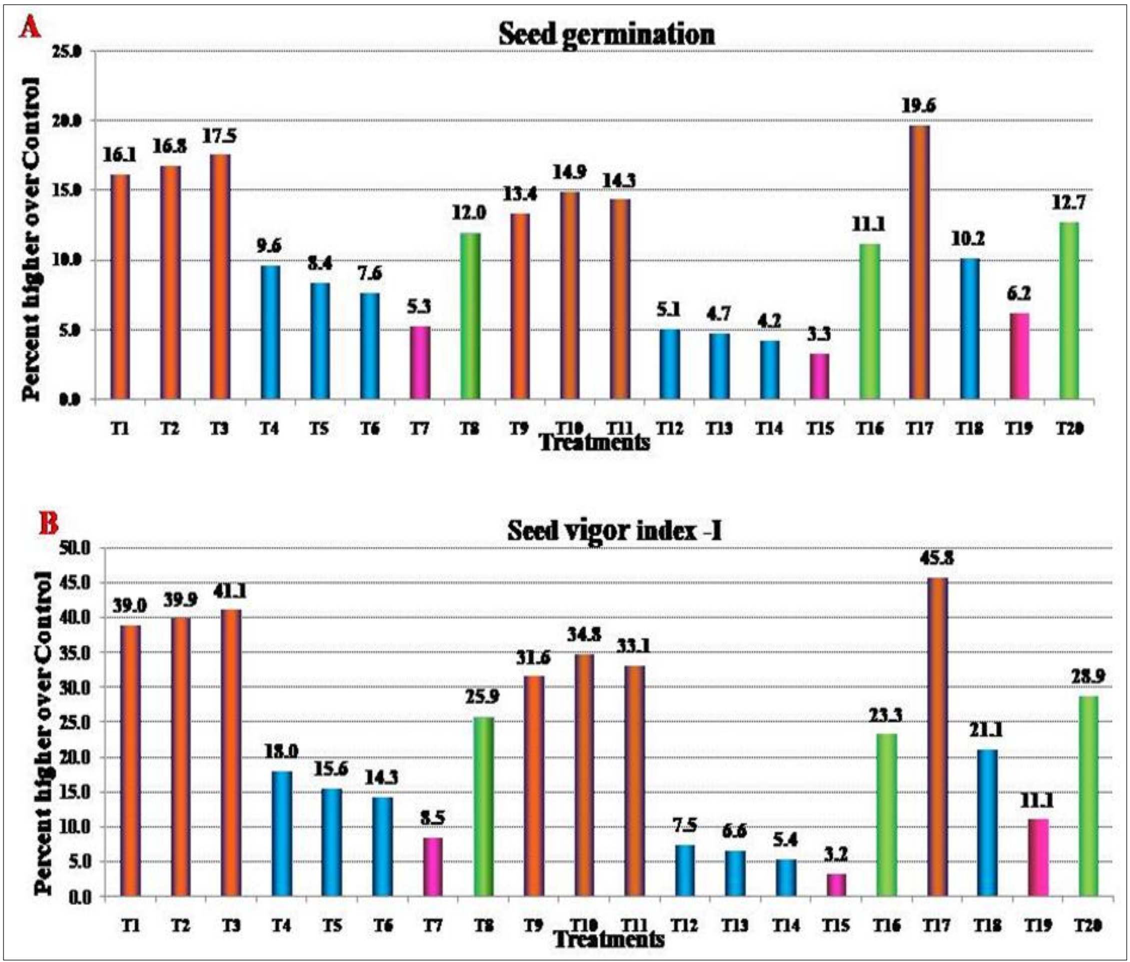

Fig 1: Percent increase in seed germination (A) and Seed vigor index-I (B) over Control of groundnut produced from seed primed and coated with borax and sodium molybdate

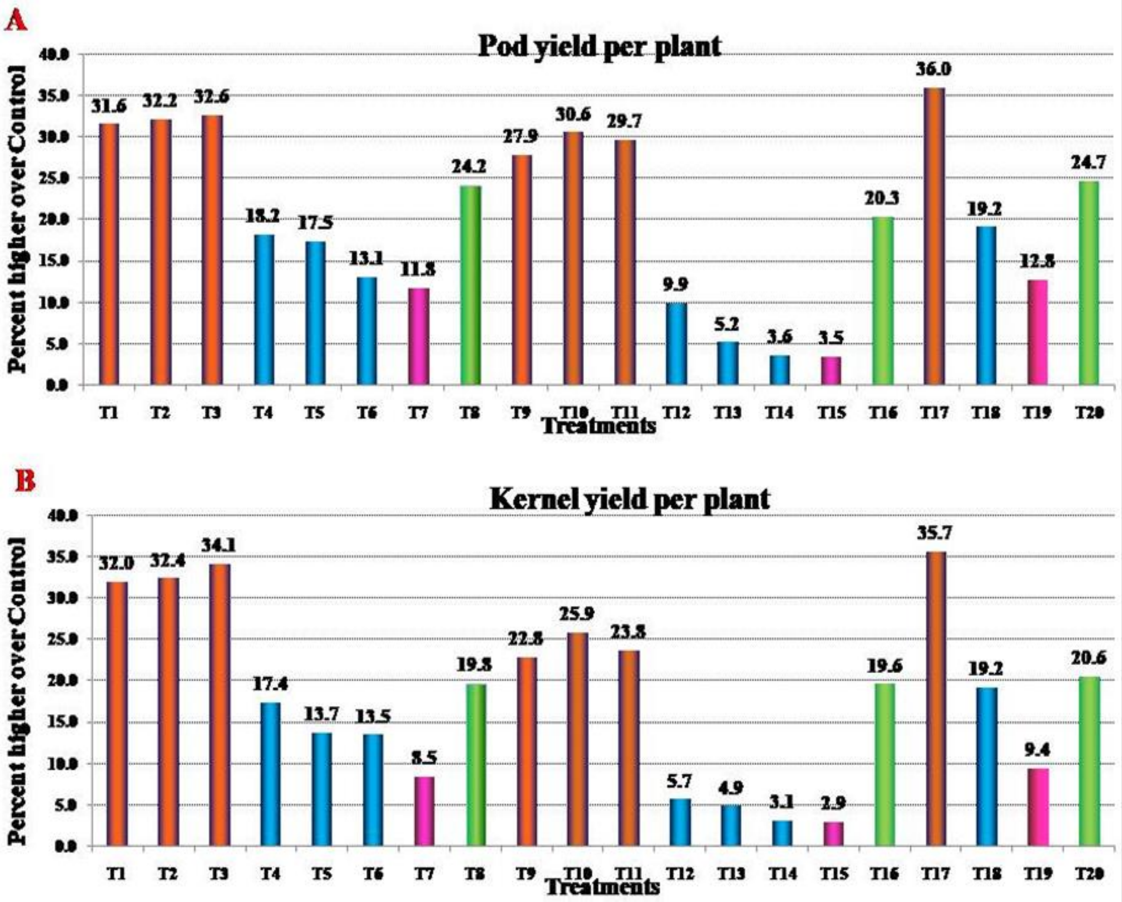

Fig 2: Percent increase in pod yield per plant (A) and Kernel yield per plant (B) over Control as influenced by priming and coating of groundnut seeds with borax and sodium molybdate

Conclusion

From the results of the present investigation, it can be concluded that priming of groundnut seeds with micronutrients, such as 0.5 g/l borax + 0.5 g/l sodium molybdate (T_{17}) for 6 hours and drying back to original moisture content was effective in improving seed physiological quality and seed yield. In general, seed priming treatments either with borax or sodium molybdate proved to be more effective than the seed coating treatments. Micronutrient delivery to crops through seed priming was found to be an effective method, in comparison to the conventional soil application and foliar spray.

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Conflicts of Interest

The authors declare no conflict of interest.

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