International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(3): 2720-2723

Received: 13-03-2019
Accepted: 15-04-2019

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Standardization of nano boron and nano zinc concentrations for effective cultivation of groundnut (*Arachis hypogaea* L.)

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Abstract
A laboratory and field experiments were conducted at Zonal Agricultural Research Station, University of Agricultural Sciences UAS, GKVK, Bengaluru during *kharif* 2018 to standardize the nano boron and nano zinc levels for effective cultivation of groundnut. Laboratory experiment consisting of six treatments laid out in a completely randomized design (CRD) with four replications. The higher germination (96.7%), root length (8.30 cm), shoot length (3.20 cm) and seedling vigour index (1112) were recorded respectively at 10 DAS when groundnut seeds primed with nano boron at 300 ppm for about 15 minutes. Similarly, seed priming with nano zinc @ 300 ppm to 600 ppm an time from 15 to 30 minutes recorded significantly higher germination, root length, shoot length (100%, 5.56 cm and 10.00 cm) and seed priming with nano zinc at 600 ppm for 60 minutes recorded significantly higher seedling vigour index (1260). After standardizing the concentration for seed priming, field experiment consists of 11 treatments laid out in randomized complete block design (RCBD) with three replications. The results showed that, seed priming with zinc sulphate @ 0.25% *fb* spraying of nano zinc @ 300 ppm at 30 DAS recorded the higher filled pods per plant, test weight, pod yield, (32.9, 30.02 g and 1856kg ha^{-1}respectively) whereas, higher haulm yield (1895kg ha^{-1}) was recorded in the treatment received seed priming of zinc sulphate @ 0.25% *fb*s praying of nano zinc @ 300 ppm at 30 DAS, higher oil content (41.94%) was recorded in the treatment consists of spraying of nanoboron@ 300 ppm at 30 DAS and higher shelling per cent (71.50%) and higher oil yield (726.56 kg ha^{-1}) were recorded in the treatment consists of seed priming with borax @ 0.2% *fb*nano boron spray @ 300 ppm at 30 DAS. Seed priming with borax @ 0.2% *fb* spraying of nano boron @ 300 ppm at 30 DAS was recorded higher plant height, number of branches, leaf area and dry matter production (44.80 cm, 8.60, 1591 cm^2 and 35.70 g/plant, respectively).

Keywords: Groundnut, germination, nano boron, nano zinc, seed priming

Introduction
India is one of the largest producers of oilseeds in the world and occupies an major position in the Indian agricultural economy. Among oilseeds, Groundnut is an important oilseed crop of India. It is the fourth most important source of edible oil and third most important source of vegetable protein. Globally, the crop is raised on 26.4 million hectares with a total production of 37.1 million MT and average productivity of 1400 kg per hectare (Anon., 2017) [1]. The average yield of groundnut is about 1212 kg per hectare in India which is low compare to world average productivity. Several reasons attributed for low yield in groundnut, one of the major reason for low yield is nutrient deficiencies. Introduction of high yielding varieties and adoption of new agricultural technology for exploiting their potential have led to wide spread deficiencies of micronutrients, especially boron and zinc. As boron helps in root and nodule development which directly helps in nitrogen fixation in plant tissues and zinc helps in activating the enzymes that are responsible for the synthesis of certain proteins, it is also essential in the formation of auxins, which help in growth regulation and stem elongation. The deficiency of boron and zinc in soils and in groundnut plants leads to poor quality and low yield of kernels. The deficiency of boron and zinc could be corrected by using boron sources like agricol, solubor, borax *etc.*, and zinc sources like zinc sulfate and zinc oxide *etc*. However, nanotechnology has provided the feasibility of exploiting nano scale or nano structured materials as fertilizer carriers, which controls the releasing pattern of nutrients to match the uptake pattern of crop, enhances the nutrient use efficiency and reduces the cost of environmental protection. So, the nano boron and nano zinc may act as an alternate source of boron and zinc which is being recommending recently, but their effective utilization in crops

in general and groundnut in particular is scanty. Keeping this in view, lab and field experiments were carried out to optimize the dosage of nano boron and zinc for groundnut crop.

Material and method

Prior to field experimentation, two laboratory experiments carried out at ZARS, UAS, GKVK, Bengaluru to standardize the nano boron and nano zinc levels on groundnut seed germination, growth and seedling vigour.

Laboratory experiment-1

It consisted of six treatments, laid out in completely randomized design with four replications. The treatment comprised of soaking of groundnut seeds in water (blank) and different concentration of nano boron solutions. The treatment details are: T_1: Blank (water), T_2: Nano boron at 300 ppm, T_3: Nano boron at 600 ppm, T_4: Nano boron at 900 ppm, T_5: Nano boron at 1200 ppm, T_6: Nano boron at 1500 ppm. Since, nano boron having smaller particle size of 70 nm, it won't dissolve in water directly. Therefore, the nano boron particles were suspended in the hot deionised water and they are dispersed by ultrasonic vibration (100 W, 40 KHz, 50 amplitude) using sonicator for 30 minutes. Cultivar ICGV 91114 seeds were soaked in different concentrations of nano boron solutions (300, 600, 900, 1200, 1500 ppm) and with water as a control in different time period (15, 30, 60 minutes).

Laboratory experiment-2

It consisted of six treatments arranged in completely randomized design with four replications. The treatment comprised of soaking groundnut seeds in water (blank), zinc sulfate solution and different concentration of nano boron solutions. The treatment details are: T_1: Seed soaking with water (Blank), T_2: Seed priming with nano zinc @ 300 ppm, T_3: Seed priming with nano zinc @ 600 ppm, T_4: Seed priming with nano zinc @ 900 ppm, T_5: Seed priming with nano zinc @ 1200 ppm and T_6: Seed priming with nano zinc @ 1500 ppm. Since, nano zinc having small particle size of 40 nm, it won't dissolve in water directly. Therefore the nano zinc particles were suspended in the hot deionised water and they are dispersed by ultrasonic vibration (100 W, 40 KHz, 50 amplitude) using sonicator for 45 minutes. Cultivar ICGV 91114 seeds were soaked in different concentrations of nano zinc solutions (300, 600, 900, 1200, 1500 ppm) and with water as a control in different time period (15, 30, 60 minutes).

Petri plates with germination papers were used for germination test. After treating seeds with nano boron and nano zinc solutions as per the treatments, seeds were uniformly placed in petri plate using forceps and kept at room temperature (28 ± 2 °C).

Germinated seeds were counted after 10 days of sowing. Germination per cent was estimated using the formula.

$$\text{Germination (\%)} = \frac{\text{Number of germinated seeds}}{\text{Total number of seeds kept for germination}} \times 100$$

Root and shoot lengths of seedling were measured at 10 and 20 DAS using a measuring scale. Seedling vigour index was worked out using the formula given by Hosseein and Kasra, 2011.

Seedling vigor index = [Root length (cm) + Shoot length (cm)] x Germination per cent

On the basis of result of laboratory experiments, a field study was conducted during *kharif* 2018 at M-block, ZARS, UAS, GKVK, Bengaluru to study the influence of nano boron and zinc on growth and yield of groundnut. The experimental site was located at 12° 58' N latitude, 77° 35' E longitude and at an altitude of 930 m above mean sea level. Total rainfall received during the year 2018 and crop growth period was 728 mm and 343.2 mm (from July to October), respectively. The soil was red sandy loam having neutral pH (7.13), low electrical conductivity (0.16), medium in available nitrogen (368 kg ha^{-1}), phosphorus (38 kg ha^{-1}), potassium (256 kg ha^{-1}), boron (0.32 ppm) and zinc (0.34 ppm).

The experiment was laid out in randomized complete block design having 11 treatments and replicated thrice. The treatment details are;T_1: Seed priming with borax @ 0.2%, T_2: Seed priming with zinc sulphate @ 0.25%, T_3: Seed priming with nano boron @ 300 ppm, T_4: Seed priming with nano zinc @ 300 ppm, T_5: Nano boron spray @ 300 ppm at 30 DAS, T_6: Nano zinc spray @ 300 ppm at 30 DAS, T_7: Seed priming with nano boron @ 300 ppm *fb* nano boron spray @ 300 ppm at 30 DAS, T_8: Seed priming with nano zinc @ 300 ppm *fb* nano zinc spray @ 300 ppm at 30 DAS, T_9: Seed priming with borax @ 0.2% *fb* nano boron spray @ 300 ppm at 30 DAS, T_{10}: Seed priming with zinc sulphate @ 0.25% *fb* nano zinc spray @ 300 ppm at 30 DAS, and T_{11}: Seed priming with nano boron @ 300 ppm *fb* seed priming with nano zinc @ 300 ppm. The groundnut cultivar ICGV 91114 was sown at 30 x 10 cm spacing. All other agronomical aspects were followed as per the recommended package of practices. Observations were made at 30, 60, 90 DAS and at harvest in respect of growth parameters and the yield and yield parameters of groundnut were recorded at harvest by following the standard procedures. The experimental data was analyzed using the analysis of variance (ANOVA) technique. The significance of the treatment effect was judged with the help of "F" (variance ratio) table. The significant differences between the means have tested at 5 per cent probability level.

Result and discussion

Laboratory experiment

The data recorded at 10 and 20 DAS from laboratory experiment pertaining to per cent germination, root growth and shoot growth and seedling vigour index of groundnut as influenced by different concentrations of nanoboron and nanozinc at different time intervals are presented in table 1, 2, 3 and 4.

The results of laboratory experiment-1 (NB) showed that, groundnut seeds primed with nano boron at 300 ppm for about 15 minutes recorded the higher per cent germination (96.7%), root length (8.30 cm and 8.90 cm), shoot length (3.20 cm and 3.46 cm) and seedling vigour index (1112 and 1195) at 10 and 20 DAS respectively. This may be due to role of boron in cell division, cell wall development and its extension. The similar findings reported by Dubey (1996).

The results of laboratory experiment-2 (NZ) showed that, groundnut seed primed with nano zinc @ 300 ppm to 600 ppm for about 15 to 30 minutes recorded significantly higher germination per cent, root length, shoot length (100% , 5.56 cm and 10.00 cm) and it was on par with nano zinc @ 300 ppm from 15 min to 30 min (7.9 cm and 9.00 cm) and seed priming with nano zinc at 600 ppm for 60 minutes recorded significantly higher seedling vigour index (1260) and it was on par with nano zinc @ 300 ppm (1184). This might be due to increased precursor activity of nano zinc in auxin production and similar results were reported by Kobayashi

and Mizutani (1970) [7]. Similar trend followed at 20 DAS and similar findings were observed by Habtamu *et al*. (2014) [5] and Prathima *et al*. (2016) [9] in safflower and sunflower respectively.

Field experiment

The results of field experiment on "Effect of nano boron and nano zinc on growth and yield of groundnut" conducted during *kharif*2018 at M-Block, ZARS, GKVK, Bengaluru are presented in table5 and table 6.

Treatment comprised of seed priming with zinc sulphate @ 0.25% *fb* nano zinc spray @ 300 ppm at 30 DAS recorded higher filled pods per plant (32.9), test weight (30.02 g) and pod yield (1856 kg ha^{-1}). However, seed priming with borax @ 0.2% *fb* nano boron spray @ 300 ppm at 30 DAS recorded higher haulm yield (1912 kg ha^{-1}), per cent shelling (71.50%) and oil yield (730kg ha^{-1}). Higher oil content (41.94%) was obtained in the treatment consists of spraying of nano boron @ 300 ppm at 30 DAS. This was due to role of boron and zinc in better uptake of nutrients and biomass accumulation which in turn resulted in higher growth and development of crop. Similarly, the beneficial effect of boron and zinc on yield of groundnut is reported by Nasef *et al*. (2006) [8], Vishwakarma *et al.* (2008) [10] and Elayaraja. (2014) [3].

Higher plant height, number of branches, leaf area and dry matter production (44.80 cm, 8.60, 1591 cm^2 and 35.70 g/plant respectively) were recorded in treatments consists of seed priming with borax @ 0.2% *fb* nano boron spray @ 300 ppm at 30 DASand it was on par with seed priming with nano boron @ 300 ppm *fb* seed priming with nano zinc @ 300 ppm (43.98 cm, 1570 cm^2 and 35.58 g/plant respectively). This was due to role of boron and zinc in improving the meristematic activity, cell division and cell elongation. Similar findings has been reported and Geethanjali *et al.* (2015) [4].

Conclusion

Seed priming with zinc sulphate @ 0.25% *fb* nano zinc spray @ 300 ppm at 30 DAS or Seed priming with borax @ 0.2% *fb* nano boron spray @ 300 ppm at 30 DAS or Seed priming with nano boron @ 300 ppm *fb* seed priming with nano zinc @ 300 ppm would help in enhancing the growth and yield of groundnut.

Table 1: Germination, root length, shoot length and seedling vigour index of groundnut as influenced by nano boron levels

Treatments	Germination (%)			10 DAS								
				Root length (cm)			Shoot length (cm)			Seedling vigour index		
	15 min.	30 min.	1hr.	15 min.	30 min.	1hr.	15 min.	30 min.	1hr.	15 min.	30 min.	1hr.
Blank (water)	96.7	93.3	93.3	8.50	8.20	8.50	3.20	3.20	3.30	1131	1064	1101
Nano boron @ 300ppm	96.7	93.3	90.0	8.30	8.20	8.10	3.20	3.10	3.50	1112	1054	1044
Nano boron @ 600 ppm	96.7	90.0	90.0	7.20	8.30	7.50	3.30	3.20	3.80	1015	1035	1017
Nano boron @ 900ppm	90.0	86.7	90.0	8.00	7.20	7.00	1.80	1.60	1.00	882	763	720
Nano boron @ 1200 ppm	83.3	76.7	86.7	8.00	6.20	5.90	1.50	1.50	0.80	792	590	581
Nano boron @ 1500 ppm	83.3	80.0	83.4	4.00	4.00	4.20	1.20	1.20	0.50	433	416	392
SEm±	1.78	1.49	1.17	0.12	0.19	0.15	0.07	0.09	0.07	18	21	17
CD (*p*=0.05)	6.34	5.65	4.67	0.40	0.61	0.49	0.26	0.29	0.26	58	64	55

Table 2: Root length, shoot length and seedling vigour index of groundnut seedlings as influenced by nano boron levels

Treatments	20 DAS								
	Root length (cm)			Shoot length (cm)			Seedling vigour index		
	15 min.	30 min.	1hr.	15 min.	30 min.	1hr.	15 min.	30 min.	1hr.
Blank (water)	8.60	9.10	8.80	3.80	3.90	4.10	1199	1213	1204
Nano boron @ 300ppm	8.90	8.80	8.30	3.46	3.26	3.10	1195	1125	1026
Nano boron @ 600 ppm	8.10	8.70	8.30	4.10	4.10	4.30	1180	1152	1134
Nano boron @ 900ppm	8.40	8.70	8.10	2.96	2.93	2.94	1022	1008	994
Nano boron @ 1200 ppm	8.10	8.60	7.50	2.80	2.85	2.26	908	878	846
Nano boron @ 1500 ppm	5.20	5.10	5.50	1.50	2.10	2.14	558	576	637
SEm ±	0.22	0.25	0.21	0.13	0.16	0.14	23	25	22
CD (*p*=0.05)	0.65	0.73	0.62	0.41	0.52	0.46	74	79	69

Table 3: Germination, root length, shoot length and seedling vigour index of groundnut as influenced by nano zinc levels

Treatments	Germination (%)			10 DAS								
				Root length (cm)			Shoot length (cm)			Seedling vigour index		
	15 min.	30 min.	1hr.	15 min.	30 min.	1hr.	15 min.	30 min.	1hr.	15 min.	30 min.	1hr.
Blank (water)	60.0	73.30	100.0	5.00	5.50	4.50	8.00	10.00	8.00	780.0	1136	1250
Nano zinc @ 300ppm	93.3	100.0	100.0	5.00	5.50	4.50	9.00	7.90	8.20	1120	982.2	1184
Nano zinc @ 600 ppm	86.7	100.0	100.0	5.56	4.50	5.10	6.00	6.70	7.50	1002	1120	1260
Nano zinc @ 900ppm	80.0	60.00	93.30	4.00	3.00	4.50	6.00	5.50	7.00	800.0	510.0	1072
Nano zinc @ 1200 ppm	86.7	66.70	99.78	3.00	4.00	4.20	6.50	5.50	5.20	823.6	633.6	937.9
Nano zinc @ 1500 ppm	40.0	20.00	67.00	2.70	3.50	2.90	4.30	6.00	5.00	653.1	950.0	790.0
SEm±	0.82	0.68	0.94	0.8	0.6	0.9	0.12	0.11	0.15	2.52	2.31	2.90
CD (*p*=0.05)	2.48	1.97	2.82	2.32	1.74	2.61	0.34	0.31	0.43	7.35	6.46	8.12

Table 4: Root length, shoot length and seedling vigour index of groundnut seedlings as influenced by nano zinc levels

Treatments	20 DAS								
	Root length (cm)			Shoot length (cm)			Seedling vigour index		
	15 min.	30 min.	1hr.	15 min.	30 min.	1hr.	15 min.	30 min.	1hr.
Blank (water)	5.00	5.50	4.50	8.00	10.00	8.00	780.0	1136	1250
Nano zinc @ 300ppm	5.00	5.50	4.50	9.00	7.90	8.20	1120	982.2	1184
Nano zinc @ 600 ppm	5.56	4.50	5.10	6.00	6.70	7.50	1002	1120	1260
Nano zinc @ 900ppm	4.00	3.00	4.50	6.00	5.50	7.00	800.0	510.0	1072
Nano zinc @ 1200 ppm	3.00	4.00	4.20	6.50	5.50	5.20	823.6	633.6	937.9
Nano zinc @ 1500 ppm	2.70	3.50	2.90	4.30	6.00	5.00	653.1	950.0	790.0
SEm ±	0.8	0.6	0.9	0.12	0.11	0.15	2.52	2.31	2.90
CD (*p*=0.05)	2.32	1.74	2.61	0.34	0.31	0.43	7.35	6.46	8.12

Table 5: Effect of different levels and methods of application of nano boron and nano zinc on growth attributes of groundnut at 90 DAS

Treatments	Plant height (cm)	Number of branches	Leaf area (cm^2)	Dry matter (g/plant)
T_1	30.40	8.10	1365	28.00
T_2	29.30	7.90	1341	30.50
T_3	35.80	8.20	1396	32.40
T_4	33.60	7.53	1405	33.30
T_5	32.90	8.30	1423	31.40
T_6	29.50	7.80	1412	30.50
T_7	43.70	8.30	1506	34.90
T_8	42.00	8.10	1495	34.50
T_9	44.80	8.60	1591	35.70
T_{10}	43.75	8.37	1545	35.55
T_{11}	43.98	8.45	1570	35.58
SEm	1.35	0.07	17.36	0.54
CD @ 5%	1.76	0.08	22.67	0.71

Table 6: Effect of different levels &methods of application of nano boron and nano zinc on yield and yield attributes of groundnut

Treatments	Filled pods per plant	Test weight (g)	Pod yield (kg/ha)	Haulm yield (kg/ha)	Shelling (%)	Oil content (%)	Oil yield (kg/ha)
T_1	23.5	24.4	1391	1588	65.30	39.87	554.00
T_2	24.8	26.86	1390	1640	64.80	40.50	562.95
T_3	27.7	28.22	1525	1601	69.90	38.65	589.00
T_4	26.9	26.95	1505	1649	65.20	41.14	611.34
T_5	27.2	27.32	1580	1621	67.10	41.94	663.00
T_6	28.5	27.59	1640	1589	66.50	39.75	580.35
T_7	30.2	28.57	1763	1871	70.40	41.46	711.00
T_8	32.6	29.20	1792	1787	69.67	41.78	638.39
T_9	31.1	29.22	1806	1912	71.50	41.00	730.00
T_{10}	32.9	30.02	1856	1895	70.50	39.43	704.21
T_{11}	31.8	29.85	1802	1878	70.79	40.32	726.56
SEm	0.67	0.36	36.72	29.31	0.69	NS	13.75
CD @ 5%	0.88	0.47	47.96	38.28	0.90	NS	17.95

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