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Effect of nano scale plant nutrients on seedling characters of Blackgram (*Vigna mungo* (L.) Hepper)

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Abstract
A laboratory study was taken up during 2017 at Crop Physiology laboratory, S.V. Agricultural College, Tirupati where blackgram seeds were treated with nano scale oxides of Zn, Mg and Fe at different concentrations along with bulk $ZnSO_4$, $MgSO_4$ and $FeSO_4$ (@ 0.2%) on seedling characters of blackgram. Significant differences were observed among treatments under each micronutrient. Blackgram seeds responded variably towards the treatments of both bulk $FeSO_4$, $MgSO_4$ and $ZnSO_4$ and nano scale Fe Oxide, Mg Oxide aand Zn Oxide particles. Among the treatments nano scale Zn Oxide @ 200ppm, nano scale Mg Oxide @ 100ppm and nano scale Fe Oxide @ 200ppm recorded higher seedling vigour index (SVI) compared to respective bulk treatments. The study reveals the promontory effect of nano particles depends on its concentration and nano scale Zn Oxide @ 200ppm, Mg Oxide @ 100ppm and Fe Oxide @ 200ppm found effective in enhancing seed germination and seedling growth of blackgram.

Keywords: Blackgram seed-Nano scale Oxides-Bulk nutrients-Zn, Mg, Fe

Introduction
Vigna mungo is also known as blackgram, originated in India, where it has been in cultivation from ancient times and is one of the most highly prized pulses of India. It is cultivated throughout India. Blackgram has also been introduced to other tropical areas mainly by Indian immigrants. It is an erect, sub erect or trailing, densely hairy annual herb. The tap root produces a branched root system with smooth, rounded nodules. The pods are narrow, cylindrical and long up to 6 cm. The seeds are rich in protein and starch.

Nanotechnology is a fascinating field of science dealing with atom by atom manipulation that yields, processes and products which are likely to transfer traditional farming into precision agriculture Subramanian and Tarafdar, 2011) [7]. Nanomaterials have gained increasing attention because of their novel properties, including a large specific surface area and high reaction activity (Yan *et al*., 2011) [9]. Nanotechnology permits broad advances in agricultural research, such as reproductive science and technology, conversion of agricultural and food wastes to energy and other useful byproducts through enzymatic nanobioprocessing, disease prevention and treatment in plants using various nanocides (Patolsky *et al*., 2006) [4]. Nanoparticles provide an efficient means to distribute pesticides and fertilizers in a controlled fashion with high site specificity thus reducing collateral damage (Remya *et al*., 2010) [6]. Several studies have been undertaken to determine both positive and negative effects of nanoparticles on seed. Seed treatments improve the physiological quality of the seeds germinability and seedling growth. In this study, the promotory or inhibitory effects of different concentrations of nano scale Oxides of Zn, Mg and Fe on the growth of blackgram was investigated. In plants, micronutrients are transported by chelators (Waters and Sankaram, 2011) [8]; however, the efficacy is low. The present study was carried out to assess the effect of nano scale Oxides of Zn, Mg and Fe in improving the seed vigour in blackgram (*Vigna mungo* (L.) Hepper) genotypes *viz*., TBG-104 and LBG-623.

Material and Methods
A laboratory experiment was conducted in Crop Physiology laboratory, S.V. Agricultural College, Tirupati with completely randomized design replicated thrice consists 10 sub treatments (including 1 control) under each main treatment.

Nano scale Oxides of Zn, Mg, Fe were procured from Nanotechnology laboratory, Institute of Frontier Technology, RARS, Tirupati. These nano scale micro nutrients were synthesized and characterized for size, shape and colloidal properties at the source lab.

Bulk micronutrients *viz*., $ZnSO_4$, $MgSO_4$, $FeSO_4$ (@ 0.2%) was used as per earlier recommendations. However dosage of nano scale Oxides of Zn, Mg, Fe for blackgram seed treatment was not yet recommended and hence dosage was identified based on promontory/ inhibitory effects on plant growth. Nano scale Zn Oxide (100, 200, 400, 600, 800 and 1000ppm), Mg Oxide (50, 100, 200, 400, 600 and 800ppm) and Fe Oxide (10, 50, 100, 200, 400 and 500ppm) concentrations were taken for evaluation.

Seeds of uniform size were selected to minimize errors in seed germination and seedling vigor. Seeds were treated with 1% bavistin to avoid contamination. The materials were suspended directly in deionized water and dispersed by ultrasonic vibration (100 W, 40 KHz) for 30 minutes. Magnetic bars were placed in the suspensions for stirring before use to avoid aggregation of the particles. 10 blackgram seeds were soaked in 100 ml of these solutions of bulk and nano for three hours. Three replicates were maintained. The pH of all the prepared solutions was found to be 6.8-7.0. A control was also maintained, corresponding to pure water. Treated blackgram seeds were placed in a petridish with one piece of sterilized filter paper and daily add 5ml of corresponding solution to each petri dish and add 5 ml of water for control. After seven days, maximum seeds were germinated and developed into normal seedlings and data was recorded on 8th day after imposing treatment.

Germination was calculated based on the number of seeds germinated in a petriplate having 10 seeds and expressed as germination percentage. Germination count was taken daily and root and shoot length observations were taken on eighth day after experiment.

1. **Germination percentage:** Germination test each with three replicates of 10 seeds was carried out in petriplates. The test conditions of 25 ± 2 ^{0}C and 95 ± 3 per cent RH were maintained in the germination room. At the end of 8 days, the number of normal seedlings was counted and the mean was expressed as percentage (ISTA, 2005).

2. **Length of Shoot:** Shoot length of all the normal seedlings from the germination test was measured from collar region to the shoot apex and the mean was expressed in centimetre.

3. **Length of Root:** Root length of all the normal seedlings from the germination test was measured from collar region to the root tip and the mean was expressed in centimetre.

4. **Seedling Vigour Index (SVI):** Seedling Vigor index was computed by adopting the method suggested by (Abdul-Baki and Anderson, 1973) and expressed as whole number.

Seedling Vigour Index (%) = Germination percentage × Seedling length in cm (Root length + Shoot length)

Results and Discussion

The results of present investigation revealed existence of treatmental variability among the bulk and nano scale micronutrient treatments (Zn, Mg and Fe) for germination percentage, root length, shoot length and seedling vigour index (SVI).

Among the Zn bulk and nano scale treatments nano scale Zn Oxide @ 200 ppm recorded higher mean seed germination (98.33 %), seedling shoot length (11.87 cm), seedling root length (3.02 cm), seedling vigour index (1462.60) followed by bulk $ZnSO_4$ @ 0.2% compared to other nano scale Zn forms and control (Table 1). Similar results for higher seedling vigour index in nano scale Zn Oxide compared to bulk $ZnSO_4$ in tomato was observed by Khanm *et al*. (2017) [3].

Among the Mg bulk and nano scale treatments nano scale Mg Oxide @ 100 ppm recorded higher mean seed germination (100.00%), seedling shoot length (11.99 cm), seedling root length (5.04 cm), seedling vigour index (1703.10) followed by bulk $MgSO_4$ @ 0.2% and nano scale Mg Oxide @ 50 ppm compared to other nano scale Mg forms and control (Table 2). Similar results were reported by Jyarambabu *et al.* (2016) [2] who stated that the highest mean vigor index value of maize was observed in 100 mg of MgO nanoparticles and the lowest mean vigor index value was recorded in control.

Among the Fe bulk and nano scale treatments nano scale Fe Oxide @ 200 ppm recorded higher mean seed germination (96.70 %), seedling shoot length (11.49 cm), seedling root length (3.94 cm), seedling vigour index (1491.20) followed by bulk $FeSO_4$ @0.2% and nano scale Fe Oxide @ 400 ppm compared to other nano scale Fe forms and control (Table 3). Similarly Raju and Rai (2017) who stated that seedling vigor index of pigeonpea was significantly higher in nano scale Fe Oxide @ 200ppm compared to bulk $FeSO_4$ @ 0.2%.

Table 1: Effect of nano scale Zn Oxide on Germination percentage (%), Shoot length (cm), Root length (cm) and Seedling Vigour Index (SVI) of blackgram genotypes

	Germination percentage (%)			Shoot length (cm)			Root length (cm)			Seedling Vigor Index (SVI)		
Treatments	**G_1**	**G_2**	**Mean**	**G_1**	**G_2**	**Mean**	**G_1**	**G_2**	**Mean**	**G_1**	**G_2**	**Mean**
Control	100.00	93.33	96.67	10.00	8.34	9.17	2.10	1.62	1.86	1210.0	924.7	1067.4
$ZnSO_4$ @ 0.2%	100.00	100.00	100.00	10.61	10.28	10.45	2.37	2.69	2.53	1298.0	1296.7	1297.3
Nano scale Zn Oxide @ 100ppm	87.67	86.67	87.17	10.61	8.59	9.60	2.47	2.24	2.36	1148.0	935.7	1041.8
Nano scale Zn Oxide @ 200ppm	100.00	96.67	98.33	13.16	10.58	11.87	2.83	3.20	3.02	1598.9	1326.3	1462.6
Nano scale Zn Oxide @ 400ppm	93.33	90.00	91.67	9.60	8.77	9.18	0.76	0.84	0.80	972.9	870.8	921.8
Nano scale Zn Oxide @ 600ppm	96.67	96.67	96.67	11.16	7.96	9.56	1.04	0.86	0.95	1178.0	837.4	1007.7
Nano scale Zn Oxide @ 800ppm	90.00	96.67	93.33	10.09	9.19	9.64	1.46	0.48	0.97	1049.9	940.6	995.2
Nano scale Zn Oxide @ 1000ppm	83.33	83.33	83.33	11.63	9.72	10.68	1.43	0.61	1.02	1083.7	865.6	974.6
Mean	93.88	92.92		10.86	9.18		1.81	1.57		1192.4	999.7	
	T	G	T x G	T	G	T x G	T	G	T x G	T	G	T x G
SE m ±	2.386	1.193	3.374	1.1586	0.5793	1.6385	0.2915	0.1457	0.4122	110.698	55.349	156.551
CD (P=0.05)	6.875	NS	NS	NS	1.670	NS	0.8402	NS	NS	319.051	159.526	NS

G_1: TBG-104, G_2: LBG-623

Table 2: Effect of nano scale Mg Oxide on Germination percentage (%), Shoot length (cm), Root length (cm) and Seedling Vigour Index (SVI) of blackgram genotypes

	Germination percentage (%)			Shoot length (cm)			Root length (cm)			Seedling Vigor Index (SVI)		
Treatments	**G_1**	**G_2**	**Mean**	**G_1**	**G_2**	**Mean**	**G_1**	**G_2**	**Mean**	**G_1**	**G_2**	**Mean**
Control	100.0	93.3	96.7	10.00	8.34	9.17	2.10	1.62	1.86	1210.0	924.8	1067.4
$MgSO_4$ @ 0.2%	93.3	93.3	93.3	11.83	12.79	12.31	3.43	3.17	3.30	1429.8	1487.2	1458.5
Nano scale Mg Oxide @ 50ppm	93.3	93.3	93.3	11.67	9.72	10.69	3.47	3.77	3.62	1414.2	1248.2	1331.2
Nano scale Mg Oxide @ 100ppm	100.0	100.0	100.0	13.72	10.27	11.99	5.96	4.11	5.04	1967.9	1438.3	1703.1
Nano scale Mg Oxide @ 200ppm	86.7	93.3	90.0	8.68	7.62	8.15	2.27	3.20	2.73	951.4	1015.8	983.6
Nano scale Mg Oxide @ 400ppm	100.0	86.7	93.3	11.80	10.13	10.97	2.06	1.59	1.82	1385.2	1016.3	1200.7
Nano scale Mg Oxide @ 600ppm	90.0	93.3	91.7	10.42	7.45	8.93	1.78	1.80	1.79	1084.6	863.1	973.9
Nano scale Mg Oxide @ 800ppm	93.3	80.0	86.7	5.88	6.69	6.28	0.32	2.16	1.24	577.7	707.3	642.5
Mean	94.6	91.7		10.50	9.13		2.67	2.68		1252.2	1087.6	
	T	G	T x G	T	G	T x G	T	G	T x G	T	G	T x G
SE m ±	3.118	1.559	4.4096	0.645	0.322	0.912	0.308	0.154	0.435	78.203	39.101	110.595
CD (P=0.05)	NS	NS	NS	1.858	0.929	NS	0.886	NS	1.253	225.393	112.69	NS

G_1: TBG-104, G_2: LBG-623

Table 3: Effect of nano scale Fe Oxide on Germination percentage (%), Shoot length (cm), Root length (cm) and Seedling Vigour Index (SVI) of blackgram genotypes

	Germination percentage (%)			Shoot length (cm)			Root length (cm)			Seedling Vigor Index (SVI)		
Treatments	**G_1**	**G_2**	**Mean**	**G_1**	**G_2**	**Mean**	**G_1**	**G_2**	**Mean**	**G_1**	**G_2**	**Mean**
Control	100.0	93.3	96.7	10.00	8.34	9.17	2.10	1.62	1.86	1210.0	924.7	1067.4
$FeSO_4$ @ 0.2%	96.7	93.3	95.0	10.88	9.28	10.08	3.65	3.17	3.41	1399.5	1157.3	1278.4
Nano scale Fe Oxide @ 10ppm	96.7	73.3	85.0	5.48	3.89	4.68	0.48	0.44	0.46	561.3	279.7	420.5
Nano scale Fe Oxide @ 50ppm	86.7	83.3	85.0	5.22	9.29	7.26	1.24	2.43	1.84	566.0	1028.7	797.3
Nano scale Fe Oxide @ 100ppm	93.3	86.7	90.0	8.74	10.69	9.72	1.53	2.70	2.12	947.7	1168.7	1058.2
Nano scale Fe Oxide @ 200ppm	100.0	93.3	96.7	11.54	11.43	11.49	4.06	3.83	3.94	1560.0	1422.3	1491.2
Nano scale Fe Oxide @ 400ppm	96.7	76.7	86.7	9.12	14.03	11.58	2.28	3.44	2.86	1112.6	1354.7	1233.6
Nano scale Fe Oxide @ 500ppm	93.3	63.3	78.3	12.61	10.56	11.58	2.12	2.78	2.45	1425.4	930.9	1178.2
Mean	95.4	82.9		9.20	9.69		2.18	2.55		1097.8	1033.4	
	T	G	T x G	T	G	T x G	T	G	T x G	T	G	T x G
SE m ±	3.486	1.743	4.930	1.247	0.624	1.764	0.419	0.210	0.593	148.814	74.407	210.455
CD (P=0.05)	10.048	5.024	NS	3.595	NS	NS	1.208	NS	NS	428.907	NS	NS

G_1: TBG-104, G_2: LBG-623

Conclusion

It can be concluded that the seeds are treated with different nano and bulk micronutrient concentrations are effective on blackgram seed, compared to control. Among the various nano scale concentrations, nano scale Zn Oxide @ 200ppm, nano scale Mg Oxide @ 100ppm and nano scale Fe Oxide @ 200ppm showed higher on germination percentage and seedling vigour index. Finally it's concluded that among the different concentrations nano scale Zn Oxide @ 200ppm, nano scale Mg Oxide @ 100ppm and nano scale Fe Oxide @ 200ppm showed promontory results compared to other nano treatments, can be used to enhance quality of the blackgram seed.

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