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Research Communication

Productivity, nutrient uptake and economics of groundnut (*Arachis hypogaea*)-toria (*Brassica rapa* subsp. *dichatoma*) cropping system as influenced by direct and residual effects of micronutrient and liming

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ABSTARCT

A field experiment was conducted at the ICAR Research complex for NEH Region, Umiam, Meghalaya, during the rainy (*kharif*) and winter (*rabi*) seasons of 2013, to assess the direct and residual effect of micronutrients and liming on productivity, nutrient uptake and economics of groundnut (*Arachis hypogaea* L.)–toria [(*Brassica rapa* subsp. *dichotoma* (Roxb.) Hanelt)] cropping system. The experiment was laid out in a factorial randomized block design with 6 micronutrients (soil application) treatments, viz. control (no micronutrient), Zn @ 5 kg/ha, B @ 1 kg/ha, Mo @ 0.5 kg/ha, Zn + Mo, Zn + B + Mo, and 2 levels of lime, viz. lime @ 500 kg/ha (application in furrow) and no lime. Sole application of Mo produced significantly higher yield of groundnut (1.72 t/ha) compared to control (1.32 t/ha) and was at par with Zn + Mo (1.78 t/ha) and Zn + B + Mo (1.8 t/ha). The maximum yield of succeeding toria was recorded with the residual effect of Zn + B + Mo (0.53 t/ha) which remained at par with residual effect of B (0.52 t/ha). Direct and residual effects of liming increased the yield of groundnut and of succeeding toria by 13.3% and 21.9%, respectively, over no liming. Integrated application of Zn + Mo and Zn +B + Mo recorded significantly highest N, P and K uptake of groundnut, whereas, residual effect of combined application of Zn + B + Mo recorded the highest N, P and K uptake of succeeding toria. Direct effect of Mo in groundnut and residual effect of B in toria was more pronounced in enhancing productivity and nutrient uptake than other sole micro nutrient application. Direct and residual effect of Zn +B + Mo resulted in the highest groundnut-equivalent yield (2.18 t/ha) and net returns (₹52.8/ha) of the system which was at par with Zn + Mo (2.11 t/ha and ₹49.8/ha, respectively).

Key words **:** Acid soil, Groundnut, Liming, Micronutrients, Nutrient uptake, Productivity, Toria

Groundnut is a very important leguminous oilseed crop with high nutritive value of its kernels, containing 43.6% edible oil and 25.3% protein. It is cultivated on nearly 4.19 million ha area with 6.68 million tonnes production and average productivity of 1.59 t/ha in India (DGR, 2015). Application of micronutrients in deficient soils, either through soil, foliar spray or seed treatment can increase yield, nutritional value of produce and enhance nutrient-use efficiency (Malakouti, 2009). Zinc (Zn), boron (B) and molybdenum (Mo) are 3 most deficient micronutrients in acidic soils of India, with their deficiency reported in 45, 46 and 31% of the agricultural soils respectively (Singh, 2007). Soil acidity is another major constraint in limiting crop productivity in north-eastern region (NER) of India, which is mainly due to the accompanying effects of Al and Mn toxicity and nutrient deficiencies and their consequential detrimental effects on crop growth and yield. Toria (*Brassica* sp.) is a potential crop for post-rainy season which can be cultivated with residual soil moisture after groundnut harvesting. Groundnut–rapeseed system is a suitable legume–non-legume combination not only for production of oilseeds but also for sustaining soil fertility. Application of major nutrients (NPK) along with lime continues to be a general recommendation for crop production, acid soils with disproportionately lesser emphasis on micronutrient fertilization. In this context, it is envisaged that application of micronutrients without concurrent use of lime may not be adequate to improve growth and productivity of micronutrient-sensitive crops, particularly

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oilseeds.

A field experiment was conducted at upgard Agronomy field, ICAR Research complex for NEH Region, Umiam, Meghalaya during the rainy (*kharif*) and winter (*rabi*) season of 2013. In the *kharif* season, groundnut ('ICGH 76') was sown at a spacing of 30 cm × 10 cm with 30, 60 and 40 kg N, P_2O_5 and K_2O/ha, respectively. The plot size was 4m × 3m (12/m^2) with adequate drainage facility. The experiment was laid out in a factorial randomized block design (FRBD) with 6 micronutrient treatments, viz. control (no micronutrient), Zn @ 5 kg/ha, B @ 1 kg/ha, Mo @ 0.5 kg/ha, Zn + Mo, Zn + B + Mo (all the micronutrients were applied through soil), and 2 soil-amendment levels, viz. lime @ 500 kg/ha (furrow application) and no lime. The fertilizers used as a micronutrient sources were zinc sulphate (22% Zn), borax (11% B) and ammonium molybdate (56% Mo). In succeeding *rabi* season in the same plots, toria was sown at 30 cm row-to-row spacing with 50, 60 and 40 kg N, P_2O_5 and K_2O/ha, respectively to evaluate the residual effect of treatments applied to groundnut on performance of toria. Groundnut was sown on 1 June 2013 and harvested on 22 September 2013, whereas toria sown on 5 October 2013 and harvested on 31 December 2013. All the recommended agronomic practices such as weed management, pest and disease management were followed for groundnut and succeeding toria crops. For yield attributes, 5 plants were selected randomly from each plot at maturity for both groundnut and toria crop. Number of pods/plant, number of kernels/pod, pod weight and kernel weight/plant were recorded for groundnut. In toria, number of siliquae/plant, siliqua length and seeds/siliqua were recorded. In groundnut, seed index (100-seed weight) and in toria, test weight (1,000-seed weight) were recorded. Pod/seed and straw/haulm yield of crops were obtained following standard procedure. Groundnut-equivalent yield (GEY) for toria was obtained by multiplying seed yield of toria with its market price (₹30/kg) and divided by the market price of groundnut kernel (₹40/kg). The GEY of toria was then added to groundnut kernel yield to obtain GEY of the system.The system productivity was obtained by adding the yield of each crop in a cropping system divided by total duration of cropping system (by adding duration of respective crops) and expressed in kg/ha/day. Macro- (N, P and K) and micronutrients (Zn, B and Mo) uptake were estimated by following standard procedures. For the sequences, the value of the main products and by-products in monetary terms was calculated separately based on prevailing market price and was recorded on unit area basis. Net return was worked out by subtracting the cost of cultivation from the corresponding gross return. Benefit: cost ratio was calculated by dividing gross return with cost of cultivation. Data obtained from the study were statistically analyzed in FRBD using the technique of analysis of variance. The difference between the treatments means were tested as to their statistical significance with appropriate critical difference (CD) value at 5% level of probability.

Results revealed that application of micronutrients significantly improved all the yield attributes of groundnut. Sole application of Mo recorded significantly higher number of kernels/pod, pod weight/plant and seed index than the control (no micronutrients) and remained at par with other treatments. Being acidic soil, application of lime significantly improved all yield parameters of groundnut over no-lime application (Table 1). The Mo supplement proved significantly more beneficial in increasing kernel yield, pod yield and harvest index of groundnut than the control and remained at par with combined application of Zn + Mo and Zn + B + Mo. Liming increased the kernel yield by 16.2%, pod yield by 13.3% and harvest index by 7.6% over no-lime application (Table 1). Micronutrients play an important role in increasing legume yield through their effect on the plant itself, nitrogen-fixing symbiotic process and effective use of major and secondary nutrients. In present study, an application of Mo increased the kernel yield by 30.7%, pod yield by 15% and harvest index by, 5.8%, respectively over the control. This is perhaps owing to better uptake and assimilation of available nutrients by the plants during the entire growth period (Valenciano *et al.,* 2010). Lime helps to increase soil *p*H, which provides favourable condition for nutrient availability to plants and adequate supply of Ca for better pod development of groundnut (Ranjit *et al.,* 2007).

All yield attributes of toria significantly improved owing to residual effect of micronutrients applied to preceding groundnut crop. Distinctly superior results were obtained under residual effect of Zn + B + Mo which was followed by residual effect of Zn + B and B. The control gave the lowest number of siliquae/plant. Residual effect of B resulted in the maximum siliqua length and seeds/siliqua of toria which was followed by residual effect of Zn, Zn + Mo and Zn + B + Mo. Residual effect of all the micronutrient treatments recorded similar 1,000-seed weight of toria which was significantly higher than the control. Residual effect of lime gave significantly higher number of siliqua/plant, siliqua length, seeds/siliqua and test weight over no-lime application (Table 1). Residual effect of B resulted in significantly higher seed yield, stover yield and harvest index of toria compared to the control and remained at par with residual effect of Zn + B + Mo. Residual effect of lime significantly increased the seed yield of toria by 23.1%, stover yield by 13.6%, and harvest index by 3.4% over no liming (Table 1). The positive role of B in the synthesis of protein and amino acids

Table 1. Yield attributes and yield of groundnut and toria and economics of cropping system as influenced by direct and residual effect of treatment

Treatment	Yield attributes of groundnut (DE)			Yield of groundnut (DE)			Yield attributes of toria (RE)				Yield of toria(RE)			Economics of cropping system (CE)			
Micronutrient	Kernels/ pod	Pod weight/ plant (g)	Seed index (g)	Kernel yield (t/ha)	Pod yield (t/ha)	Harvest index (%)	Siliquae/ plant	Siliqua length (cm)	Seeds/ siliqua	1,000-weight (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)	GEY (t/ha)	System productivity (kg/ha/ day)	Net returns ($\times10^3$ /ha)	Benefit: cost ratio
Control	2.1	12.6	42.6	1.32	2.50	20.8	15.1	3.3	15.7	2.7	0.39	0.45	28.0	1.61	8.5	29.7	1.73
Zinc (Zn)	2.1	16.4	48.2	1.62	2.70	21.8	18.1	4.2	19.3	3.0	0.48	0.53	29.7	1.99	10.6	45.3	2.12
Boron (B)	2.1	16.3	46.3	1.56	2.63	22.0	18.9	4.3	19.6	3.0	0.52	0.59	30.5	1.96	10.4	44.1	2.08
Molybdenum- (Mo)	2.2	17.3	48.7	1.72	2.88	22.0	17.8	4.1	18.8	3.0	0.42	0.49	28.5	2.04	10.7	46.8	2.16
Zn + Mo	2.2	17.6	49.3	1.78	2.90	22.4	19.3	4.2	19.7	3.0	0.44	0.50	29.2	2.11	11.1	49.8	2.22
Zn + B + Mo	2.2	17.8	49.4	1.80	2.90	22.5	19.9	4.2	19.8	3.0	0.53	0.61	30.3	2.18	11.6	52.8	2.29
SEm±	0.02	0.35	0.34	0.02	0.03	0.4	0.16	0.02	0.18	0.03	0.01	0.01	0.8	0.03	0.1	1.00	0.02
CD (P=0.05)	0.06	1.02	0.99	0.07	0.10	1.3	0.48	0.07	0.54	0.10	0.03	0.04	2.2	0.07	0.3	2.94	0.07
Soil amendment																	
Lime	2.2	19.0	50.9	1.76	2.92	60.0	20.8	4.2	20.1	3.3	0.51	0.56	29.9	2.14	11.3	50.0	2.20
No Lime	2.1	13.7	43.6	1.51	2.58	58.5	15.6	3.9	17.5	2.6	0.42	0.49	28.9	1.82	9.6	39.5	2.00
SEm±	0.01	0.12	0.11	0.01	0.01	0.36	0.05	0.01	0.06	0.01	0.004	0.004	0.3	0.008	0.0	0.33	0.01
CD (P=0.05)	0.02	0.34	0.33	0.02	0.03	1.04	0.16	0.02	0.18	0.03	0.011	0.013	0.7	0.024	0.1	0.98	0.02

DE, Direct effect of treatments; RE, residual effect of treatment; CE, cumulative effect of treatment; GEY, groundnut yield equivalent

might have increased the yield (Chitdeshwari and Poongothai 2003). Residual effect of lime lasts for few years after application and improves phosphorus availability and increase yield (Rahman *et al.* 2002).

The GEY of groundnut–toria system was recorded significantly higher owing to combined application of Zn + B + Mo over the control and remained at par with application of Zn + Mo, which were superior to rest of the treatments (Table 1). This was owing to favourable effect of combined application of micronutrients which enhanced the productivity of groundnut and succeeding toria (Chaudhary *et al.,* 2014). System productivity was the highest with combined application of Zn + B + Mo and was superior to the remaining treatments. The lowest system productivity was noted under the control. Considering the system as a whole, application of Zn + B + Mo and Zn + Mo to groundnut and their residual effect on toria resulted in significantly higher net return and benefit: cost ratio compared with the control and other micronutrients. Application of lime significantly increased GEY, system productivity, net returns and benefit: cost ratio of groundnut-toria cropping system over no-lime application (Table 1), as liming improved the soil *p*H and improved the availability of micronutrients to crops.

Direct and residual effect of micronutrient and lime significantly enhanced N, P and K uptake of groundnut and toria over the control. The maximum N uptake was recorded in combined application of Zn + Mo, which was followed by Zn + B + Mo. However, sole application of Mo recorded significantly higher P uptake of groundnut over the control and remained at par with combined application of Zn + Mo and Zn + B + Mo. Application of lime significantly influenced N, P and K uptake of groundnut (Table 2). This may be attributed to the increase in haulm and kernel yields owing to increased availability of micronutrients. Patil and Ananthanarayana (1989) reported that presence of lime accelerates the rate of nitrification which is the reason for increased N content in groundnut that ultimately increase N uptake. Increase in P uptake because of liming may be due to the fact that it breaks the Al and Fe phosphates in soil, thereby making P available to plant. Further, improvement in available P status may be owing to increase in mineralization of organic P as affected by lime (Haynes, 1992).

The maximum N, P and K uptake by toria was recorded because of residual effect of Zn + B + Mo, whereas the control exhibited the lowest N, P and K uptake. Due to residual effect of lime, N, P and K uptake by toria increased significantly over no-liming. The increase in N, P and K uptake of toria due to residual effect of Zn + B + Mo were 50.2, 76 and 45.5% over the control, respectively (Table 2). Residual effect of lime resulted in significantly

Table 2. Macro- and micronutrients uptake by groundnut and toria as influenced by direct and residual effect of treatment

Treatment	Macronutrient uptake by groundnut (kg/ha)[DE]			Macronutrient uptake by toria (kg/ha)[RE]			Micronutrient uptake by groundnut (g/ha)[DE]			Micronutrient uptake by toria (g/ha)[RE]		
Micronutrient	N	P	K	N	P	K	Zn	B	Mo	Zn	B	Mo
Control	92.2	5.9	26.1	16.9	1.38	7.7	96.8	130.2	5.0	21.0	23.9	0.57
Zinc (Zn)	135.0	8.0	36.0	23.5	1.98	9.7	163.5	184.1	8.3	28.9	30.5	0.75
Boron (B)	127.8	8.9	35.5	25.2	2.04	11.1	123.8	215.1	6.9	26.2	40.5	0.82
Molybdenum (Mo)	142.4	11.0	39.1	20.2	1.87	9.1	140.2	173.5	10.1	22.8	27.6	0.82
Zn + Mo	147.7	10.0	40.3	21.4	2.14	9.2	173.7	223.3	10.6	27.2	29.2	0.83
Zn + B + Mo	147.2	10.8	40.9	25.4	2.43	11.2	176.4	234.7	10.9	33.1	43.8	0.99
SEm±	1.63	0.18	0.90	0.5	0.05	0.3	4.45	5.4	0.1	0.7	1.0	0.02
CD (P=0.05)	4.89	0.54	2.70	1.5	0.15	0.6	13.35	16.2	0.3	2.1	3.0	0.06
Soil amendment												
Lime	144.7	11.0	38.9	24.7	2.40	11.5	156.9	221.5	10.3	31.6	38.6	0.98
No Lime	119.4	7.20	33.7	19.5	1.54	7.9	134.6	165.5	7.0	21.5	26.5	0.61
SEm±	0.54	0.06	0.30	0.2	0.02	0.1	1.48	1.8	0.04	0.2	0.3	0.005
CD (P=0.05)	1.62	0.18	0.90	0.6	0.06	0.3	4.44	5.4	0.12	0.7	1.0	0.015

DE, Direct effect of treatments; RE, residual effect of treatment

higher N, P and K contents in seed and shoots and also increased their uptake in succeeding toria crop over no-liming.

The Zn uptake of groundnut was significantly higher with the application of Zn + B + Mo over the control and was at par with treatment Zn + Mo and Zn (Table 2). The maximum B and Mo uptake was recorded owing to combined application of Zn + B + Mo, which was followed by Zn+Mo and Mo. Application of lime significantly increased the Zn, B and Mo uptake of groundnut than no-lime application. The Maximum Zn, B and Mo uptake was recorded because of residual effect of Zn + B + Mo, whereas the control gave the lowest Zn, B and Mo uptake. Residual effect of lime significantly improved micronutrient uptake over no-lime application (Table 2). Influence of micronutrients in succeeding crop might be owing to the reason that micronutrients are required in very small amount and some amount is left for next crop (Kumar and Qureshi, 2012). Residual effect of lime significantly influenced micronutrient content in seed and shoot and their uptake by toria in acid soil.

REFERENCES

Chitdeshwari, T. and Poongothai, S. 2003. Yield of groundnut and its nutrient uptake as influenced by zinc, boron and sulphur. *Agricultural Science Digest* **23**(4): 263–266.

DGR, Junagadh. 2015. *Annual Report 2014–15*, ICAR-Directorate of Groundnut Research, Junagadh, Gujarat, India.

Haynes, R.J. 1992. Effects of liming on phosphate availability in acid soils. *Plant and Soil* **68**(3).

Kumar, M. and Qureshi, F.M. 2012. Dynamics of zinc fractions, availability to wheat (*Triticum aestivum* L.) and residual effect on succeeding maize (*Zea mays* L.) in inceptisols. *Journal of Agricultural Science* **4**(6): 236–245.

Malakouti, M.J. 2009. The effect of micronutrients in ensuring efficient use of macronutrients. *Turkish Journal of Agriculture and Forestry* **32**(3): 215–220.

Patil, P.L. and Ananthanarayana, R. 1989. Effect of lime level as indicated by different methods on soil properties. *Karnataka Journal of Agricultural Science* **2**: 273–380.

Rahman, M.A., Meisner, C.A., Duxbury, J.M., Lauren, J., Hossain, A.B.S. 2002. Yield response and change in soil nutrient availability by application of lime, fertilizer and micronutrients in acidic soil in a rice–wheat cropping system. *17th World Congress on Soil Science*, 14–21 August 2002, Thailand.

Ranjit, R., Dasog, G.S. and Patil, P.L. 2007. Effect of lime and phosphorus levels on the pod, haulm and oil yield of the two groundnut genotypes in acid soils of coastal agro eco system of karnataka. *Karnataka Journal of Agricultural Science* **20**(3): 627–630.

Singh, M.V. 2007. Problems of micro- and secondary-nutrients in acidic soils of India and their management. (In) *Bulletin of the Indian Society of Soil Science* **25**: 27–58 Rattan, R.K. (Ed).

Valenciano, J.B., Bato, J.A. and Marcelo, V. 2010. Response of chickpea (*Cicer arientinum* L.) yield to zinc, boron and molybdenum application under pot conditions. *Spanish Journal of Agricultural Research* **8**: 797–807.