Indian J. Plant Physiol., Vol. 12, No. 1, (N.S.) pp. 72-77 (Jan.-Mar., 2007)

MACRONUTRIENT REQUIREMENT OF GROUNDNUT : EFFECTS ON UPTAKE OF MACRONUTRIENTS

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Received on 2 Dec., 2005, Revised on 28 Nov. 2006

SUMMARY

A series of sand culture pot experiments were conducted to find-out the required concentrations of macronutrients in the nutrient solution, for growing groundnut. The groundnut variety JL 24 was grown at 2, 5, 10, 20, 50, 100, 150 and 200 ppm levels of each of N, P, K, Ca and S, separately. The uptake of these macronutrients by groundnut were determined. The study revealed that increasing levels of N, P, K, Ca and S upto 100, 50, 100, 200, and 20 ppm, respectively of these macronutrients, in the nutrient solution, increased their uptake. There was an interaction among macronutrient absorption. Increasing N level increased P, K, Ca and Mg, increasing K level decreased Ca and Mg and increasing Ca level decreased K and Mg concentrations in plant tissues and their uptake. The P and S, however, did not show any interaction effects with other macronutrients. The crop received balanced nutrition and showed best growth at 50, 20, 50, 50, and 20 ppm, levels of N, P, K, Ca and S, respectively.

Key words: **Groundnut, macronutrients, sand culture, uptake.**

INTRODUCTION

Groundnut is cultivated worldwide on almost all soil types and requires all macro- and micro-nutrients for its growth and development with high requirement as compared to many other crops, (Cox *et al*. 1970, 1982, Dwivedi 1988, Hartzog and Adams 1988, Singh 1999, 2004). Being comparatively a drought tolerant crop with low transpiration, the groundnut is susceptible to nutritional disorders due to insufficient supply of minerals (Beringer and Taha 1976).

The nutrient requirement of groundnut crop in the field has been worked out by several workers (Cox *et al*. 1982, Kanwar *et al*. 1983, Bell 1985, Dwivedi 1988, Singh 1999, Singh *et al*. 1995) but no sand/solution culture studies have been conducted pinpointing the macronutrient composition which can provide an adequate supply of all these to groundnut at a concentration as low as compatible with adequate rate of absorption and growth. A series of pot experiments were conducted to study the uptake of macronutrients in plant tissues of groundnut grown at various levels of N, P, K, Ca and S, in the nutrient solutions, and to find out suitable concentrations of these macronutrients for groundnut. The growth, dry matter production and yield of groundnut at different levels of macronutrients have been reported (Singh and Chaudhari 2006). This paper deals with the uptake of macronutrients by groundnut at maturity.

MATERIALS AND METHODS

Sand culture pot experiments were conducted at the National Research Centre for Groundnut, Junagadh, India during the wet (July sown) and dry (Feb. sown) cropping seasons. The effect of different levels (2, 5, 10, 20, 50, 100, 150, and 200 ppm) of N, P, K, Ca and S separately and uptake of these macronutrients was examined. Fifteen

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kg of sand was filled in pots of 25 cm diameter and the healthy seeds of groundnut variety JL 24 were sown at a rate of four seeds per pot. The details of the experimental procedures and the nutrient solution used in the study are described elsewhere (Singh and Chaudhari 2006).

The plant samples taken at maturity were washed, separated into leaves, stems and pods, dried in oven at 60°C for about a week and weighed. The oven dried plant samples were ground to a fine powder and analyzed for total nitrogen by auto analyzer, P by colorimetry, S by turbidimetry (Chaudhary and Cornfield 1966), Ca and Mg by titrimetry, and K by flame photometry. The concentrations of Ca, Mg and K, being in low quantity in seed samples, were analyzed by atomic absorption spectrophotometer. The uptake of these macronutrients was calculated by multiplying the nutrient concentrations by their respective dry matter. All these data were analyzed statistically by anaylsis of variance.

RESULTS AND DISCUSSION

The nutrients uptake by groundnut at maturity, was affected due to various levels of macronutrients in nutrient solution during both the seasons. The significant changes in the uptake of macronutrients are discussed separately for each nutrient in the following text.

Effects of nitrogen levels

The uptake of N, P, K, Ca, S and Mg by groundnut at maturity increased with increasing levels of N, in the nutrient solution, significantly up to 50 ppm N during wet season. However, during dry season, though sufficient uptake of all these macronutrients were observed at 50 ppm of N, the uptake of N, P, K, S and Mg increased up to 200 ppm of N (Table 1). The dry season crop, due to more pod and haulm yields, showed higher uptake of macronutrients showing more efficient utilization of nutrients per unit dry matter production. These observations support our earlier studies (Singh and Joshi 1993, Singh *et al*. 1995). The nitrogen requirement of groundnut is much higher than cereals because of its high protein contents, but most of it is being met through nitrogen-fixation. The recommended levels of N in the Hoagland's solution is 210 ppm (Hewitt 1966), but in this study, due to intensive nodulation and N2-fixation by root nodules, the groundnut showed good growth and yield at 50 ppm of N. Though enough nodulation was observed at lower levels of N, these were not sufficient enough to meet the N requirement of the crop especially during the early growth and at pod filling phases and hence required additional N, which was met with 50 ppm of N in the nutrient solution in this study. The higher levels of N than 50 ppm decreased nodulation and hence were not beneficial.

Table 1. Effects of different levels of N, in nutrient solution, on the macronutrients uptake (mg pot^{-1}) by groundnut at maturity during wet and dry cropping seasons.

Nitrogen	Wet season						Dry season					
levels (ppm)	N	P	K	Ca	S	Mg	N	P	K	Ca	S	Mg
2	135	17	107	154	16	40	303	27	252	313	30	102
5	259	27	200	279	25	76	427	38	342	400	39	126
10	337	30	229	330	27	86	592	52	440	580	41	149
20	457	41	297	404	36	100	777	64	519	640	53	169
50	713	67	383	529	49	135	1032	102	685	844	66	208
100	743	64	391	483	45	109	1140	101	765	1002	69	233
150	744	67	379	448	47	109	1224	112	821	943	81	238
200	769	67	398	470	47	108	1345	118	913	949	84	257
LSD (0.05)	75	8	66	50	9	13	121	11	78	56	9	20

Effects of phosphorus levels

Increasing the P levels of nutrient solution, unlike N, did not affect the concentrations of other macronutrients in plant tissues (Figs. 1, 2 and 3). However, the uptake of macronutrients increased significantly due to increase in pod yield and total dry matter production with increasing levels of P up to 20 ppm during wet season and up to 50 ppm during dry season. In a field experiment, Lombin and Singh (1986) observed increase in Ca concentration of leaves, haulms and kernels and N concentration of kernels due to P application. However, field and pot studies at several occasions revealed increase in nitrogen fixation (Singh 2004). The P application, in this study, increased the nodulation, which in turn increased N_2-fixation and N contents of the kernel and foliage, but this increase was not significant. On an average the uptakes of N, P, K, Ca, S, and Mg were 555, 51, 282, 290, 42, and 73 mg pot^{-1}, respectively during wet season and 836, 100, 692, 789, 79, and 185 mg pot^{-1}, respectively during dry season at 20 ppm levels of P (Table 2).

Effects of potassium levels

The applications of K, unlike N and P had varied effects on the macronutrient absorption by groundnut. The uptake of macronutrients, due to increase in yield and dry matter, increased significantly with increasing the levels of K up to 50 ppm (Table 3). The 200 ppm K, though showed significantly higher uptake of N, P, and K, but lower Ca and Mg uptakes than that of 50 ppm K (Table 3). This indicated that at low levels of K, the cations like Ca and Mg were more absorbed by plant to balance the anions, but these were proportionally taken up at 50 ppm levels of K. Such antagonistic effects of K on Ca and Mg are well known in other crops (Jones *et al*. 1991). Thus 50 ppm level of K, in the nutrient solution, was most suitable for balanced absorption and uptakes of most of the macronutrients.

Effects of calcium levels

Like K, calcium also had varied effects on the absorption and uptake of macronutrients clearly indicating the synergistic and antagonistic nature of the Ca in absorption of other macronutrients. The uptake of all the macronutrients by groundnut increased significantly with increasing Ca levels up to 50 ppm, in the nutrient solution (Table 4). Increasing the Ca levels above 50 ppm, though increased N, P, and Ca uptake, it did not affect K, Mg and S uptake due to reduction in the concentrations of K and Mg in the plant tissues (Table 4). The uptakes N, P, K, Ca, S and Mg were 526-867, 52-91, 257-596, 344-

Table 2. Effects of different levels of P, in nutrient solution, on the macronutrients uptake (mg pot^{-1}) by groundnut at maturity during wet and dry seasons.

Phosphorus	Wet season						Dry season					
levels (ppm)	N	P	K	Ca	S	Mg	N	P	K	Ca	S	Mg
2	172	9	98	127	13	32	231	15	196	249	21	63
5	259	18	145	170	19	43	524	43	478	576	44	137
10	333	26	185	213	25	53	737	63	596	742	61	169
20	555	51	282	290	42	73	836	100	692	759	79	185
50	531	52	268	279	38	68	966	121	788	885	84	227
100	526	54	275	304	41	76	969	125	758	896	89	227
150	545	58	289	306	45	77	975	125	814	1025	94	213
200	561	68	290	301	47	74	997	137	802	1051	97	215
LSD (0.05)	72	7	40	38	6	10	98	16	95	125	14	16

Table 3. Effects of different potassium levels, in nutrient solution, on the macronutrients uptake (mg pot^{-1} = * 0.2 kg ha^{-1}) by groundnut at maturity during wet and dry seasons.

Potassium	Wet season						Dry season					
levels (ppm)	N	P	K	Ca	S	Mg	N	P	K	Ca	S	Mg
2	244	19	67	204	15	42	236	26	102	366	25	74
5	379	31	118	258	24	51	342	38	194	506	36	100
10	423	39	182	336	32	70	499	54	311	567	48	110
20	497	51	236	368	39	84	677	70	470	701	59	131
50	558	55	311	365	43	85	815	86	742	712	67	145
100	555	53	319	336	40	74	858	90	823	665	65	139
150	525	55	334	323	39	77	864	84	809	550	64	129
200	619	61	379	313	47	76	918	94	848	542	67	122
LSD (0.05)	44	6	51	29	5	8	35	12	58	45	8	14

Table 4. Effects of different calcium levels, in nutrient solution, on the macronutrients uptake (mg pot^{-1} = * 0.2 kg ha^{-1}) by groundnut at maturity during wet and dry seasons.

Calcium	Wet season						Dry season					
levels (ppm)	N	P	K	Ca	S	Mg	N	P	K	Ca	S	Mg
2	152	16	116	59	14	39	284	35	312	120	32	103
5	249	25	164	93	19	47	408	47	401	230	42	126
10	308	33	219	151	25	67	503	67	483	364	52	150
20	434	42	260	253	31	62	625	72	497	580	54	143
50	526	52	257	344	38	78	867	91	596	858	67	159
100	544	54	252	360	36	69	908	100	593	920	71	136
150	574	53	271	394	41	67	1007	93	605	1058	77	159
200	660	61	294	448	42	64	1013	95	588	1098	73	141
LSD (0.05)	48	8	23	34	6	9	41	9	78	60	9	16

858, 38-67 and 78-159 mg pot^{-1}, respectively at 50 ppm Ca level, in the nutrient solution.

Effects of sulphur levels

Increasing the levels of S, though, increased only S concentration of plant tissues, the uptakes of all the macronutrients increased significantly with increasing levels of S in the nutrient solution due to increase in yield and dry matter (Table 5). Here also significant increase in the uptake of most of the macronutrients was observed up to 20 ppm of S, except the 200 ppm S which showed significantly higher uptake than 20 ppm for most of the macronutrients. This was again due to increase in dry

Table 5. Effects of different sulphur levels, in nutrient solution, on the macronutrients uptake (mg pot^{-1} = * 0.2 kg ha^{-1}) by groundnut at maturity during wet and dry seasons.

Sulphur	Wet season						Dry season					
levels (ppm)	N	P	K	Ca	S	Mg	N	P	K	Ca	S	Mg
2	198	20	137	161	13	41	316	40	309	364	20	98
5	297	29	190	228	19	56	489	57	445	525	37	135
10	376	38	210	261	24	63	668	74	551	656	63	150
20	498	47	263	316	40	74	839	89	590	719	86	168
50	526	48	273	323	42	76	931	88	654	788	94	187
100	539	49	263	325	44	75	929	91	657	778	98	179
150	542	49	256	331	47	74	964	93	646	816	107	179
200	598	58	277	362	55	81	1035	97	678	905	120	206
LSD (0.05)	40	8	20	30	5	7	89	11	38	56	12	15

matter and sulphur contents of plant tissues. At 20 ppm of S, the uptakes of N, P, K, Ca, S, and Mg were sufficient enough for the groundnut.

It is concluded from the study, that the adequate supply of macronutrients compatible with growth in groundnut at maturity were achieved at 50 ppm of N, K, and Ca and at 20 ppm levels of P and S, in the nutrient solution. Increasing or decreasing levels of these macronutrients caused cation-anion imbalance in the plant tissue concentrations of macronutrients causing deficiencies of either of elements. Hence for the balance nutrition and growth, it is recommended to grow groundnut at these levels of macronutrients in the nutrient solution.

ACKNOWLEDGMENT

We gratefully acknowledge the Director, National Research Centre for Groundnut (NRCG), Junagadh, for providing facilities during the course of investigation.

REFERENCES

Bell, M.J. (1985). Phosphorus nutrition of peanut (*Arachis hypogea* L) on Cockatoo sandy of the Ord river irrigation area. *Austr. J. Exp. Agric.* **25**: 649-653.

Beringer, H. and Taha, M. A. (1976). ^{45}Calcium absorption by two cultivars of groundnut (*Arachis hypogaea* L). *Exp. Agric.* **12**: 107-111.

Chaudhary, T. A. and Cornfield, A.H. (1966). The determination of total sulphur in Soil and Plant material. *Analyst* **91** : 528-531.

Cox, F.R., Nicholaids, K.K., Reid, P. H., Hallock, D. L. and Martins, D. C. (1970). Nutrient concentration in Virginia, type peanuts during the growing season. North Carolina *Agric. Exp. Stn. Tech. Bull*. 204.

Cox, F.R., Adams, J.F. and Tucker, B.B. (1982). Liming, fertilization and mineral nutrition. In: H.E. Pette and C.T. young (Eds.), Peanut Science and Technology, pp 139-163. American Peanut Research and Education Society Inc. Yoakum, Texas, U.S.A.

Dwivedi, R.S. (1988). Mineral Nutrition of Groundnut. Metropolitan Book Co. New Delhi, India.

Hartzog, D.L. and Adams, J.F. (1988). Soil fertility experiments with peanuts in Albana, 1973-1986. *Albana Agric. Exp. Stn. Bull.* **594**: 1-39.

Hewitt, E.J. (1966). Sand and Water Culture Methods Used in the Study of Plant Nutrition. Tech. Commun. Commonwealth Agricultural Bureaux, London CAB.

Jones, Jr J. B., Wolf, B. and Mills, H. A. (1991). Plant Analysis Handbook. Micro-Macro Publishing Inc. Georgia, U.S.A.

Kanwar, J.S., Nighawan, H.L. and Raheja, S.K. (1983). Groundnut Nutrition and Fertilizer Response in India. ICAR Publication, New Delhi.

Lombin, G. and Singh, L. (1986). Fertilizer responses of groundnuts (*Arachis hypogea* L.) under continuous intensive cultivation in the Nigerian Savanah. *Fert. Res.* **10**: 43-58.

Singh A.L. (1999). Mineral nutrition of groundnut. In: A. Hemantranjan (Ed.), Advances in Plant Physiology Vol II, pp. 161-200. Scientific Publishers (India), Jodhpur.

Singh A.L. (2004). Mineral nutrient requirement, their disorders and remedies in Groundnut. In: M.S. Basu and N.B. Singh (Eds.), Groundnut Research in India, pp 137-159. National Research Center for Groundnut (ICAR), Junagadh, India.

Singh, A. L. and Chaudhari, Vidya. (2006). Macronutrients requirement of groundnut : Effects on growth and yield components. *Indian J. Plant Physio.* **11:** 401-409.

Singh, A.L. and Joshi, Y.C. (1993). Comparative studies on the chlorophyll contents, growth, N uptake and yield of groundnut varieties of different habit groups. *Oleagineux*, **48**: 29-34.

Singh, A.L., Chaudhari Vidya, Koradia V.G and Zala, P.V. (1995). Effect of excess irrigation and iron and sulphur fertilizers on the chlorosis, dry matter production, yield and nutrient uptake by groundnut in calcareous soil. *Agrochimica* **39** : 184-198.