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Response of boron and molybdenum on groundnut (*Arachis hypogaea* L.) under medium black calcareous soil

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Abstract
A pot experiment was conducted at Department of Agricultural Chemistry and Soil Science, College of Agriculture, Junagadh during summer season of 2016 to evaluate soil application of boron and molybdenum and its effect on Growth parameters, yield attributes, yield, nutrient content, uptake, and quality parameters of summer groundnut (*Arachis hypogaea* L.) and post harvest soil fertility. The experiment comprising of five levels of boron viz., 0, 2, 4, 8 and 10 kg B ha^{-1} and three levels of molybdenum viz., 0, 1, 2 kg Mo ha^{-1} and experiment was laid out in Factorial Completely Randomization Design and replicated thrice. The results revealed that the application of boron 8 kg B ha^{-1} and molybdenum 1 kg Mo ha^{-1} significantly increased the Growth parameters, yield attributes, yield, nutrient content, uptake, and quality parameters of summer groundnut (*Arachis hypogaea* L.) and post harvest soil fertility under medium black calcareous soils of south Saurashtra region of Gujarat.

Keywords: *Arachis hypogaea* L., boron, molybdenum, nodulation

Introduction
Groundnut (*Arachis hypogaea* L.) is a legume crop of family *Fabaceae* (or *Leguminosae*) mostly grown for its edible seeds and oil production in the world. It is also known as pea-nut. It is native to South America (Brazil), best grown in tropical and sub tropical region of the world at a latitudes 400 N to 400 S. The groundnut seed is called kernel which is used in confectionary nut flour production, protein and peanut milk. Seed oil content of groundnut is 46-52%, while carbohydrates and protein percentage is 18 and 30% respectively. Like other legumes groundnut has the capacity to fix atmospheric nitrogen through symbiotic nitrogen fixing bacteria in root nodules which mean peanut plant required less N containing fertilizers, it also improve N content in soil which make this plant valuable in crop rotation (Sakarvadia *et al.*, 2019) [26]. In India, groundnut is grown in 11 states, accounts for 29 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 75.72 lakh tones and productivity is about 1210 kg ha^{-1} in India. Though the share of groundnut in the total oil seed production in India has been falling since 1950, when it was 70% to the present level of 33%, groundnut is still a major oilseed crop in India. Its production decides not only the price of groundnut oil in any year, but also the price of most of other edible oils.

Kharif groundnut is grown under rainfed situations and the summer groundnut is grown under assured irrigated conditions. Hence summer groundnut is much less likely to suffer moister deficient and consequently the average productivity (about 1500 kg ha^{-1}) is higher to *kharif* groundnut (about 1000 kg ha^{-1}). As the *kharif* groundnut continuous to be risk prone due to vagaries of monsoon, opportunities of realizing further incremental growth in average national. Groundnut is annually grown on about 24 M ha of land in about 120 countries under different agro-climatic zones between 400S and 400N (Anon., 2013) [3]. In India, it is cultivated on an area of 5.53 M ha with production of 9.67 M tones and productivity of 1750 kg ha^{-1} during 2013-2014 (Anon., 2015) [5]. Gujarat produce 6.84 M tonnes of oilseed with the share of 20.80% Gujarat are leading state in term of total oilseed production. In India total groundnut production is 9.67 M tones from area of 5.5 M ha, with Gujarat produce 4.92 M tones which share 50% of total groundnut production (Anon., 2014) [4]

Groundnut production in Saurashtra exhibited diminishing trend during last three decade, this may be partly because of nutritional disorder caused due to continuous mono cropping of groundnut. Boron is one of them as the soils are calcareous, which restricts the boron availability. Boron is unique among the essential mineral micronutrients because it is the only element that is normally present in soil solution as a non - ionized molecule over the pH range suitable for plant growth. Boron is involved in the transformation of sugar and starch formation. It also influences cell development and elongation. Boron affects carbohydrate metabolisms and starch formation and synthesis of proteins of proteins. Addition of boron (2 ppm) in groundnut increased the yield by 18 per cent (Golakiya and Patel, 1986a) [12] and improved the quality (Golakiya, 1988) through suitable changes in yield attributes (Sutaria and Golakiya, 1990) [32]. Molybdenum is required for the formation of the nitrate reductase enzyme and in the legume it plays an additional role in symbiotic nitrogen fixation. The nitrogen fixing enzyme, nitrogenase is composed of molybdenum and iron and without adequate quantities of these elements, nitrogen fixation can't occur. Muralidharan and George (1971) [18] found that Mo increased the vegetative growth and weight of nodular materials and finally the yield of groundnut. The studies by Noor *et al.*, 1997 [22] indicated that application of molybdenum increased the yield, nodulation and oil content in groundnut. The functions of molybdenum in leguminous plants include nitrate reduction, nodulation, nitrogen fixation and general metabolism (Togay *et al.*, 2008) [35].

Materials and Methods

The pot experiment was conducted at Net house, Department of Agricultural Chemistry and Soil Science, College of Agriculture, Junagadh Agricultural University, Junagadh during summer season of 2016.

Table 1: Soil physicochemical characteristics and mineral nutrient status of the experimental

soil depth (cm)	Mechanical Composition			
	Sand%	Silt%	Clay%	Texture class
0-15	15.01	28.96	56.03	Clayey

soil depth (cm)	Chemical Composition											
	$pH_{2.5}$	$EC_{2.5}$ (dS m^{-1})	O.C (g kg^{-1})	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Mo (ppm)
0-15	8.00	0.58	4.10	212.0	28.63	257.0	10.02	5.24	12.78	0.72	1.21	0.63	0.070

The experiment comprised of total fifteen treatment combinations in which five levels of boron (0, 2, 4, 8 and 10 B kg ha^{-1}) and three levels of molybdenum (0, 1 and 2 Mo kg ha^{-1}) were laid out in Completely Randomization Design having factorial concept with three replications. The fertilizer application was done with fixed doses of nitrogen at 25 kg ha^{-1}, phosphorus at 50 kg ha^{-1} and potassium at 50 kg ha^{-1}. Boron and molybdenum application was done according to the treatments. The nutrients of N, P, K, B and Mo were applied by using sources of Urea, DAP, MOP, Boric acid and Ammonium molybdate, respectively. The Groundnut variety "Gujarat Groundnut-31" was planted in fourth week of February. A week after germination five plants per each pot were maintained under normal practices. The crop was raised with all the standard package of practices and protection measures also timely carried out as they required. The experimental data recorded for growth parameters, yield attributes and yield parameters were statistically analyzed for level of significance**.**

Results and Discussion

Growth parameters, yield attributes, yield and quality parameters

Effect of boron

Branches per plant (3.89) recorded significantly the highest value with application of 10 kg B ha^{-1} (B_4). While, significantly higher value of plant height (23.30 cm), numbers of pegs per plant (26.04), number of nodules per plant (91.57) and nodules dry weight per plant (0.231 g $plant^{-1}$) were recorded with application of 8 kg B ha^{-1} (B_3) as compare to control (Table 2). Boron is important for root and shoots growth, flower fertility and responsible for the cell wall formation and stabilization. Boron is essential nutrient for nodule forming bacteria therefore, increased nodule count resulting in positive effect on biometric parameters of plants. These results already agreement with those reported by Hirpara *et al.* (2017) [13], Mallick and Raj (2015) [14] and Bhagiya *et al.* (2005) [8].

Application of 8 kg B ha^{-1} recorded significantly the highest values of number of pods per plant(10.556), number of mature pods per plant (7.572), shelling percentage (67.15), pod yield (19.75 g $plant^{-1}$). Significantly higher value of haulm yield (18.56 g $plant^{-1}$) was recorded with application of 10 kg B ha^{-1} (Table 2). As boron is required for cell differentiation, development and growth of pollen grains. Boron might have brought increase translocation of photosynthates, resulting in increased pollination and seed setting which in turn might have brought yield characters. Close agreement with the results obtained by Naiknaware *et al.* (2015) [20], Nandini *et al.* (2012) [21], Modhavadiya *et al.* (2018) [15] and Srinivasan *et al.* (2008) [31].

Application of 8 kg B ha^{-1} recorded significantly the highest values of oil content (46.25%) and test weight (43.40 g) (Table 2). Boron is important for sugar translocation. Boron play important role in synthesis of essential amino acids like cysteine, methionine and certain vitamin like biotine, thymine, Vitamin B_1 as well as the formation of ferodoxin and iron containing plants. The present findings are in close agreement with the results obtained by Venkatesh *et al.* (2006) [36] and Adkine *et al.* (2011) [1].

Effect of Molybdenum

Application of 1 kg Mo ha^{-1} recorded significantly the highest value of number of branches per plant (4.022), number of pegs per plant (21.78) at harvest, number of nodules per plant (95.01) and nodules dry weight per plant (0.236 g $plant^{-1}$) at harvest as compare to control (Table 2). Molybdenum can play a vital role in increasing the nitrogen fixation process by *Rhizobium* and is responsible for the formation of nodule tissue and increase in N_2 fixation. Molybdenum is a constituent of the *nitrogenase* enzyme and every bacterium, which fixes nitrogen, need molybdenum during the fixation process.

Table 2: Effect of boron and molybdenum on growth parameters, yield attributes, yield and quality parameters of summer groundnut at harvest

Treatments	Plant height (cm)	No. of branches per Plant	No. of pegs per plant	No. of nodules per plant	Nodules dry weight per plant (g)	No. of pods per plant	No. mature pods per plant	No.of immature pods per plant	Shelling%	Pod yield per plant (g)	Haulm yield per plant (g)	Protein content (%)	Oil content (%)	Test weight (g)
Boron levels (kg ha^{-1})														
B_0- Control	15.14	3.20	14.67	74.68	0.178	7.018	3.961	3.057	61.83	13.05	13.48	25.91	42.12	41.03
B_1 - 2	21.33	3.58	16.89	84.91	0.207	7.320	4.253	3.067	64.83	14.99	16.34	27.28	44.36	42.74
B_2 - 4	22.40	3.71	20.05	89.87	0.222	9.928	6.924	3.003	66.14	19.31	17.08	27.47	45.69	43.02
B_3 - 8	23.30	3.80	26.04	91.57	0.231	10.556	7.572	2.983	67.15	19.75	17.59	28.45	46.25	43.40
B_4- 10	22.10	3.89	25.72	91.18	0.227	10.534	7.541	2.993	66.55	19.28	18.56	28.22	46.06	43.22
S.Em±	0.63	0.07	0.51	1.16	0.003	0.176	0.121	0.058	0.87	0.34	0.41	0.64	0.51	0.58
C.D. at 5%	1.82	0.20	1.47	3.36	0.009	0.509	0.348	NS	2.52	0.99	1.17	NS	1.46	1.67
Molybdenum levels (kg ha^{-1})														
Mo_0- Control	19.87	3.22	18.79	70.28	0.170	8.576	5.510	3.066	62.52	16.04	14.44	26.57	42.69	40.78
Mo_1- 1	21.50	4.02	21.78	95.01	0.236	9.589	6.625	2.964	68.89	18.23	18.64	28.60	47.44	44.40
Mo_2- 2	21.19	3.67	21.45	94.04	0.232	9.048	6.016	3.032	64.49	17.56	16.76	27.22	44.56	42.87
S.Em±	0.49	0.05	0.40	0.90	0.002	0.137	0.093	0.045	0.68	0.26	0.31	0.49	0.39	0.45
C.D. at 5%	NS	0.15	1.14	2.60	0.007	0.395	0.270	NS	1.96	0.76	0.91	1.42	1.13	1.29
Interaction (B×Mo)														
S.Em±	1.09	0.12	0.88	2.01	0.005	0.306	0.209	0.100	1.51	0.59	0.70	1.10	0.88	1.00
C.D. at 5%	NS	NS	NS	5.81	0.016	NS	0.603	NS	NS	1.71	2.03	NS	NS	NS
C.V.%	9.0	5.6	7.4	4.0	4.3	5.8	5.9	5.7	4.02	5.93	7.32	6.96	3.4	4.0

These results already agreement with those reported by Nadia Gad (2012) [19], Aziz Abdel and Aly (2012) [7], Movalia *et al.* (2018) [17] and Mohamed *et al.* (2011) [16].

Application of 1 kg Mo ha^{-1} (Mo_1) recorded significantly the highest values of number of pods per plant (9.589), number of mature pods per plant (6.625), shelling percentage (68.89%), pod yield (18.23 g plant^{-1}) and haulm yield (18.64 g plant^{-1}) as compare to control (Table 2). Molybdenum is essential for N_2 fixation, which has ensured better N supply to the crop and activation of enzyme *nitrate reductage*, a soluble molybdoflavoprotein (Tandan, 1995) contributing to better growth and yield of the crop, nodulation, nitrogen fixation and general metabolism. The present findings are in close agreement with the results obtained by Bhagiya *et al.* (2005) [8], Hirpara *et al.* (2017) [13], Srinivasan *et al.* (2007) [30] and Biswas *et al.* (2003) [9].

Application of 1 kg Mo ha^{-1} (Mo_1) recorded significantly the highest values of protein content (28.60%), oil content (47.44%) and test weight [100 seed weight] (44.40 g) (Table 2). Molybdenum is involved in protein biosynthesis through its effect on ribonuclease and alanine aminotransferase activity. Molybdenum regulate several enzymes. The present findings are in close agreement with the results obtained by Nadia Gad (2012) [19], Mohamed *et al.* (2011) [16] and Adkine *et al.* (2011) [1].

Nutrients Concentration and Uptake

Effect of B

Significantly the higher values of B content in pod (28.76 mg kg^{-1}) and haulm (44.42 mg kg^{-1}) recorded with application of 8 kg B ha^{-1} compare to other levels of B (Table 3 & 4). The results are inclose agreement with Bhagiya *et al.* (2005) [8], Rana *et al.* (2005) [25] and Shanke *et al.* (2003) [27].

Significantly the higher values of uptake of macro and micro nutrient by haulm were recorded with application of 10 kg B ha^{-1}. While, significantly higher value of macro and micronutrient by pod were recorded with application of 8 kg B ha^{-1} compared to other levels of B (Table 5 & 6). The increase in nitrogen uptake may be due to favorable effect of boron on nodulation (Patel and Golakiya, 1986) [24]. The positive effect of boron on phosphorus uptake could be attributed to the favorable effect of the former which alters the permeability of plasma lemma at the root surface in such a way that P absorption by roots increase (Parks *et al.* 1994) [23]. The results of present investigation are in close agreements with the findings of Naiknaware *et al.* (2015) [20], Rana *et al.* (2005) [25] and Shanke *et al.* (2003) [27].

Table 3: Effect of boron and molybdenum on primary and secondary macro-nutrients content in pod and haulm

Treatments	Primary macro-nutrients content (%)						Secondary macro-nutrients content (%)					
	N		P		K		S		Ca		Mg	
	Pod	Haulm	Pod	Haulm	Pod	Haulm	Pod	Haulm	Pod	Haulm	Pod	Haulm
Boron levels (kg ha^{-1})												
B_0- Control	4.53	2.11	0.41	0.30	0.62	0.79	0.163	0.245	0.171	1.383	0.167	0.547
B_1 - 2	4.59	2.19	0.43	0.30	0.63	0.80	0.165	0.248	0.172	1.392	0.170	0.571
B_2 - 4	4.70	2.22	0.44	0.31	0.63	0.81	0.170	0.262	0.173	1.410	0.181	0.582
B_3 - 8	4.69	2.28	0.45	0.31	0.64	0.83	0.173	0.268	0.178	1.416	0.188	0.590
B_4- 10	4.60	2.25	0.44	0.31	0.64	0.80	0.171	0.265	0.176	1.423	0.183	0.598
S.Em±	0.078	0.042	0.008	0.005	0.018	0.031	0.006	0.007	0.005	0.027	0.006	0.015

C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Molybdenum levels (kg ha^{-1})												
Mo_0-Control	4.23	2.12	0.42	0.30	0.61	0.81	0.167	0.251	0.169	1.384	0.172	0.555
Mo_1- 1	4.87	2.29	0.45	0.31	0.65	0.81	0.170	0.265	0.179	1.422	0.184	0.596
Mo_2- 2	4.78	2.22	0.43	0.30	0.64	0.79	0.168	0.256	0.174	1.408	0.177	0.582
S.Em±	0.061	0.033	0.006	0.004	0.014	0.024	0.005	0.006	0.004	0.021	0.005	0.012
C.D. at 5%	0.175	0.094	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (B × Mo)												
S.Em±	0.136	0.073	0.0142	0.009	0.030	0.054	0.011	0.013	0.0083	0.047	0.0102	0.026
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V.%	5.0	5.7	5.6	4.9	8.2	9.6	9.2	8.5	8.2	5.7	9.8	7.7

Table 4: Effect of boron and molybdenum on micro-nutrients content in pod and haulm

Treatments	Micro-nutrients content (mg kg^{-1})											
	Fe		Mn		Zn		Cu		B		Mo	
	Pod	Haulm	Pod	Haulm	Pod	Haulm	Pod	Haulm	Pod	Haulm	Pod	Haulm
Boron levels (kg ha^{-1})												
B_0- Control	466.7	642.6	44.20	104.3	63.08	51.28	30.88	34.43	22.57	32.89	0.444	0.761
B_1 - 2	471.4	654.6	44.75	105.3	63.80	51.87	31.19	34.79	24.40	41.44	0.454	0.761
B_2 - 4	477.6	658.1	45.37	106.3	65.23	53.46	31.66	35.51	27.90	43.07	0.457	0.785
B_3 - 8	478.8	659.5	45.62	107.0	66.33	54.18	32.24	36.07	28.76	44.42	0.469	0.795
B_4- 10	478.1	658.8	45.76	106.9	65.46	54.41	31.80	36.10	28.66	43.63	0.464	0.792
S.Em±	8.0	11.0	0.89	1.6	1.35	1.17	0.86	0.49	0.67	0.98	0.009	0.014
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	1.93	2.83	NS	NS
Molybdenum levels (kg ha^{-1})												
Mo_0-Control	467.1	638.6	44.18	103.8	63.44	51.24	30.43	34.71	25.72	40.26	0.392	0.647
Mo_1- 1	485.4	666.9	46.43	108.0	66.96	54.09	32.78	36.09	27.49	41.87	0.493	0.858
Mo_2- 2	471.1	658.6	44.81	106.1	63.94	53.78	31.45	35.34	26.15	41.14	0.486	0.832
S.Em±	6.2	8.5	0.69	1.2	1.05	0.91	0.66	0.38	0.52	0.76	0.007	0.011
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.021	0.032
Interaction (B×Mo)												
S.Em±	13.9	19.1	1.5373	2.7	2.3397	2.03	1.48	0.85	1.16	1.70	0.02	0.03
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V.%	5.1	5.1	5.9	4.5	6.3	6.6	8.2	4.2	7.6	7.2	6.2	5.6

Table 5: Effect of boron and molybdenum on primary and secondary macro-nutrients uptake by pod and haulm

Treatments	Primary macro-nutrients uptake (g $plant^{-1}$)						Secondary macro-nutrients uptake (g $plant^{-1}$)					
	N		P		K		S		Ca		Mg	
	Pod	Haulm	Pod	Haulm	Pod	Haulm	Pod	Haulm	Pod	Haulm	Pod	Haulm
Boron levels (kg ha^{-1})												
B_0- Control	0.598	0.286	0.055	0.041	0.082	0.107	0.021	0.033	0.022	0.186	0.022	0.074
B_1 - 2	0.691	0.359	0.065	0.050	0.095	0.131	0.025	0.041	0.026	0.228	0.026	0.093
B_2 - 4	0.910	0.383	0.086	0.053	0.123	0.139	0.033	0.045	0.033	0.241	0.035	0.100
B_3 - 8	0.929	0.404	0.090	0.056	0.128	0.146	0.034	0.047	0.035	0.250	0.037	0.105
B_4- 10	0.890	0.420	0.086	0.058	0.124	0.150	0.033	0.049	0.034	0.265	0.035	0.112
S.Em±	0.020	0.012	0.002	0.001	0.004	0.005	0.001	0.001	0.001	0.007	0.001	0.004
C.D. at 5%	0.057	0.036	0.007	0.004	0.010	0.014	0.004	0.004	0.003	0.019	0.004	0.012
Molybdenum levels (kg ha^{-1})												
Mo_0-Control	0.679	0.307	0.069	0.044	0.099	0.117	0.027	0.036	0.027	0.200	0.028	0.080
Mo_1- 1	0.891	0.430	0.083	0.059	0.120	0.153	0.031	0.050	0.033	0.266	0.034	0.112
Mo_2- 2	0.840	0.374	0.077	0.052	0.113	0.133	0.029	0.043	0.031	0.236	0.031	0.098
S.Em±	0.015	0.010	0.002	0.001	0.003	0.004	0.001	0.001	0.001	0.005	0.001	0.003
C.D. at 5%	0.044	0.028	0.006	0.003	0.008	0.011	0.003	0.003	0.002	0.015	0.003	0.009
Interaction (B×Mo)												
S.Em±	0.034	0.022	0.004	0.002	0.006	0.008	0.002	0.002	0.002	0.012	0.002	0.007
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V.%	7.3	10.1	9.5	8.2	9.8	10.8	12.6	9.8	10.7	8.6	12.3	12.3

Table 6: Effect of boron and molybdenum on micro-nutrients uptake by pod and haulm

Treatments	Micro-nutrients uptake (mg plant^{-1})											
	Fe		Mn		Zn		Cu		B		Mo	
	Pod	Haulm	Pod	Haulm	Pod	Haulm	Pod	Haulm	Pod	Haulm	Pod	Haulm
Boron levels (kg ha^{-1})												
B_0- Control	6.094	8.68	0.578	1.407	0.825	0.691	0.407	0.465	0.296	0.443	0.0059	0.0104
B_1 - 2	7.064	10.71	0.671	1.723	0.957	0.847	0.468	0.569	0.366	0.678	0.0068	0.0125
B_2 - 4	9.238	11.26	0.877	1.820	1.260	0.919	0.612	0.609	0.541	0.737	0.0089	0.0136
B_3 - 8	9.473	11.64	0.902	1.884	1.311	0.959	0.639	0.637	0.569	0.784	0.0093	0.0142
B_4- 10	9.228	12.24	0.884	1.989	1.264	1.014	0.615	0.672	0.554	0.811	0.0090	0.0149
S.Em±	0.223	0.31	0.023	0.049	0.032	0.031	0.021	0.018	0.018	0.022	0.0002	0.0004
C.D. at 5%	0.644	0.88	0.068	0.141	0.092	0.088	0.060	0.053	0.051	0.062	0.0006	0.0012
Molybdenum levels (kg ha^{-1})												
Mo_0-Control	7.498	9.22	0.711	1.499	1.021	0.739	0.491	0.501	0.421	0.586	0.0063	0.0093
Mo_1- 1	8.886	12.44	0.848	2.016	1.224	1.014	0.600	0.675	0.510	0.792	0.0090	0.0160
Mo_2- 2	8.275	11.05	0.789	1.778	1.125	0.905	0.554	0.594	0.465	0.694	0.0085	0.0140
S.Em±	0.173	0.24	0.018	0.038	0.025	0.024	0.016	0.014	0.014	0.017	0.0002	0.0003
C.D. at 5%	0.499	0.68	0.053	0.109	0.072	0.068	0.047	0.041	0.040	0.048	0.0006	0.0009
Interaction (B×Mo)												
S.Em±	0.386	0.53	0.041	0.085	0.055	0.053	0.036	0.032	0.031	0.037	0.0004	0.0008
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V.%	8.2	8.40	8.9	8.310	8.5	10.340	11.3	9.3	11.4	9.3	9.0	10.1

Effect of Mo

The concentration of molybdenum and nitrogen recorded significantly highest in pod and haulm with the values of (0.493 mg kg^{-1} and 0.858 mg kg^{-1}) and (4.870% and 2.297%), respectively at molybdenum applied @ 1 kg Mo ha^{-1} (Mo_1) at harvest (Table 3 & 4).

Significantly the higher values of uptake of macro and micro nutrient with application of 1 kg Mo ha^{-1} (Mo_1) compared to other levels of Mo (Table 5 & 6). The N content and its uptake by pod and haulm increased with increasing levels of molybdenum application. This might be due to the molybdenum actively participating in nodule formation of legume and structural component of *nitrogenase*, the enzyme involve in the N_2 fixation by *Rhizobium* in root nodules (Tandon, 1998). This could be synergistic effect on nitrogen metabolism in plant. The results of present investigation are in close agreements with the findings of Aziz Abdel and Aly (2012) [7], Nadia Gad *et al.* (2012) [19] and Bhagiya *et al.* (2005) [8].

Post harvest soil status of available nutrients

Effect of B: The status of available B (0.854 mg kg^{-1}) in the soil under the boron level of 8 kg B ha^{-1} significantly improved over rest levels of boron (Table 7). The significant build up of available B status under this boron level might be due to their direct adequate application to soil. The results of present investigation are conformity with results observed by Athokpan *et al.* (2008) [6], Singh *et al.* (2005) [29] and Sharma *et al.* (1999) [28].

Effect of Mo: The status of available Mo (0.079 mg kg^{-1}) in the soil under the molybdenum level of 1 kg Mo ha^{-1} (Mo_1) significantly improved over rest levels of molybdenum (Table 7). The significant build up of available Mo status under this molybdenum level could be attributed to adequate supply of Mo direct to soil. The results of present investigation are conformity with results observed by Alam *et al.* (2015) [2], Bhagiya *et al.* (2005) [8] and Dwivedi *et al.* (1990) [10].

Table 7: Effect of varying levels of boron and molybdenum on availability of macro and micro nutrients in soil after harvest of crop

Treatments	Available primary macro-nutrients (kg ha^{-1})				Available micro-nutrients (mg kg^{-1})					
	N	P	K	S	Fe	Mn	Zn	Cu	B	Mo
Boron levels (kg B ha^{-1})										
B_0- Control	208.8	30.97	250.2	10.83	4.224	10.20	0.594	1.296	0.614	0.067
B_1 - 2	215.2	29.26	252.1	10.69	4.292	10.35	0.617	1.316	0.794	0.069
B_2 - 4	222.0	32.04	252.3	11.54	4.414	10.44	0.619	1.318	0.816	0.071
B_3 - 8	221.6	32.80	254.5	11.97	4.446	10.60	0.629	1.363	0.854	0.072
B_4- 10	221.0	32.29	253.5	11.82	4.387	10.55	0.624	1.319	0.853	0.071
S.Em±	6.1	0.86	5.3	0.36	0.077	0.19	0.011	0.020	0.013	0.002
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	0.038	NS
Molybdenum levels (kg Mo ha^{-1})										
Mo_0-Control	210.3	30.94	244.1	10.95	4.307	10.20	0.605	1.302	0.772	0.053
Mo_1- 1	227.1	32.39	258.3	11.93	4.416	10.73	0.629	1.348	0.794	0.079
Mo_2- 2	215.7	31.09	255.1	11.25	4.335	10.35	0.616	1.317	0.792	0.078
S.Em±	4.7	0.67	4.1	0.28	0.060	0.15	0.009	0.016	0.010	0.002
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.004
Interaction (B×Mo)										
S.Em±	10.5	1.49	9.2	0.63	0.133	0.34	0.020	0.035	0.023	0.003
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V.%	8.4	8.2	6.3	9.6	5.3	5.6	5.5	4.6	5.1	8.2
Initial	212	28.63	257	10.02	5.24	12.78	0.723	1.21	0.637	0.070

Conclusion

Based on the experimental results, it can be concluded that obtaining higher pod and haulm yield, growth parameters, yield attributes and quality parameters, content & uptake of nutrients and available nutrients in soil after harvest of groundnut crop (Summer, Variety GJG-31) was fertilizing with boron 8 kg ha^{-1} and molybdenum 1 kg ha^{-1} in medium black calcareous soils of South Saurashtra region of Gujarat.

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