AVAILABILITY OF MOLYBDENUM FOR PLANT GROWTH IN MAJOR SOIL TYPES OF UTTAR PRADESH

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ABSTRACT

Available soil molybdenum was determined in representative samples of the six major soil types of U.P.—Bhabhar, Tarai, semi-desert and arid Alluvial, Bundelkhand types IB (Rakar) and II (Parwa), Vindhyan and Karail. Ammonium oxalate-oxalic acid, pH 3.3, extractable molybdenum in these soils ranged from 0.008 to 0.258 ppm and available molybdenum as determined by the bioassay test from 0.002 to 0.408 ppm. The Bhabhar soils were sufficient in available molybdenum. In the other soil types examined, available molybdenum ranged from deficiency to sufficiency; large proportion of samples from Tarai, arid Alluvial, Vindhyan and Karail soils falling in the deficiency range. Foliar application of molybdenum to cauliflower plants grown on representative soils of Bundelkhand types IB (Rakar) and II (Parwa) brought about marked increase in dry matter yield of plants; but no such effect was observed in Bhabhar and arid Alluvial soils; thus, there was a poor correspondence between the soil test values for available molybdenum and plant response to molybdenum amendment in arid Alluvial and Bundelkhand type IB (Rakar) soils.

INTRODUCTION

Apart from genetic and environmental factors, performance of plants on a particular soil depends upon an adequate supply of the essential nutrients which in turn is a function of the parent material from which the soil is derived and the different factors that effect its availability in the soil. Since these factors vary from soil to soil, it is but necessary to characterise the different soil types nutritionally, for predicting and improving the performance of plants growing under field conditions. In an earlier publication, CHATTERJEE, AGARWALA AND SHARMA (1976) described the vertical distribution of the micronutrients in the principal soil types of the state. This paper deals with information about the availability of molybdenum and performance of plants in these soils about which information is very limited (AGARWALA, SHARMA, SINHA & MEHROTRA, 1964 ; MEHROTRA & GANGWAR, 1964 ; SINGH & SINGH, 1966; PATHAK, SHANKER & MISRA, 1968).

MATERIAL AND METHODS

Collection was made of plough layer (top 0 to 8″) samples of Tarai soils from District Naini Tal, semi-desert Alluvial soils from Districts Agra and Mathura, arid Alluvial soils from District Lucknow, Bundelkhand type IB (Rakar) and type II (Parwa) soils from District Jhansi and Vindhyan and Karail soils from Districts Varanasi and Mirzapur. Soil samples were drawn from uncultivated and undisturbed areas. The soils were estimated for some physico-chemical properties—texture, calcium carbonate, organic matter, electrical conductivity in the water saturation extract (E. Ce.) and for available molybdenum.

Textural class was assigned to soils after referring the percentage of sand, silt and clay separates to the soil textural triangle (U. S. D. A. Soil Survey Staff, 1966). Soil pH was determined in 1:2.5 soil-water suspension by using Cambridge glass electrode pH

meter, calcium carbonate was determined by the rapid titration procedure described by PIPER (1942). Organic matter was determined by Walkley-Black's method as described by JACKSON (1958). E. Ce. was determined on a WTW conductivity bridge and the values are expressed as m mhos/cm at 25°C.

Available molybdenum in soils was determined by two methods : (i) by the bioassay procedure using *Aspergillus niger* as the test organism (NICHOLAS & FIELDING, 1951), (ii) by extracting the soil with 0.27 M ammonium oxalate-oxalic acid buffer, pH 3.3 by the method described by GRIGG (1953) and estimating molybdenum as molybdenum-dithiol complex by the method described by PIPER AND BECKWITH (1948) or alternatively by the bioassay procedure as described by HEWITT AND HALLAS (1951). The details of the methods have been described earlier (CHATTERJEE & AGARWALA, 1971). For expressing molybdenum concentration on oven dry basis hygroscopic moisture was determined by drying the soils in an oven at 110°C for 24 hours.

Besides soil analysis, a pot culture experiment was carried out to test the response to molybdenum application in Bhabhar, arid Alluvial and Bundelkhand types IB and II soils. Cauliflower (*Brassica oleracea* var. botrytis) was used as the test plant. For pot culture studies soils collected as above were filled in 8" clay flower pots lined on the interior with a polythene sheet. To ensure adequate plant growth, soils were supplemented with nitrogen, phosphorus and potassium at a concentration of 100 ppm N, 50 ppm P_2O_5 and 50 ppm K_2O by mixing appropriate amounts of ammonium nitrate, sodium dihydrogen orthophosphate, and potassium dihydrogen orthophosphate purified against molybdenum by co-precipitation with copper sulphide as described by HEWITT (1952). Plants were grown from seeds sown directly in pots. For watering the pots use was made of deionised water. Molybdenum application was made in the form of foliar spray of 500 ppm molybdenum supplied as sodium molybdate when plants were three weeks old. Plants were harvested at six weeks growth and dry matter yield was determined by drying the plant material at 70°C for 24 hours in a forced draft oven.

The entire data was statistically analysed. Correlations were worked out between the two methods of determining available molybdenum and in between the important soil physico-chemical characteristics and available molybdenum. Analysis of variance was carried out for testing the significance of molybdenum response in plants raised in pot culture.

RESULTS AND DISCUSSION

Available molybdenum in Uttar Pradesh soils ranged between 0.008 and 0.258 ppm as extracted by Grigg's reagent and 0.002 to 0.408 ppm as determined by the bioassay procedure (Table 1).

GRIGG (1953) had suggested 0.05 ppm molybdenum in Ammonium oxalate-oxalic acid, pH 3.3, extracts as the critical value for available soil molybdenum. The corresponding value for bioassay has been suggested to be 0.03 ppm (NICHOLAS & FIELDING, 1951). On the basis of these limits a number of soils of each of the types except Bhabhar revealed deficiency of molybdenum ; the percentage number of soils found deficient differed in different soil types.

In general, Bhabhar soils appeared to be sufficient in available molybdenum. Amm. oxalate-oxalic acid extractable molybdenum in these soils ranged between 0.086 to 0.258 ppm suggesting sufficiency. But for two soils, H4 and H6, bioassayed molybdenum in these soils was also in the sufficiency range. As would be expected on the basis of the two tests used for determining available soil molybdenum, cauliflower plants grown on the six

Table 1—Some physico-chemical characteristics and available molybdenum status of some major soil types of U.P.

Sample no	Locality	Texture	pH	% organic matter	Ca CO_3	E.Ce. m mhos per cm	ppm molybdenum	
							Grigg's method	Bioassay method
1	2	3	4	5	6	7	8	9
		Tarai soils (Nainital district)						
R 1	Rudrapur	L	8.1	2.01	3.00	1.20	0.023	0.040
R 2	Rudrapur	L	7.6	1.21	1.50	0.92	0.047	0.051
R 3	Matkota	SL	7.8	1.61	1.00	2.03	0.034	0.080
R 4	Matkota	SL	7.1	1.20	0.75	..	0.101	..
R 5	Patharchatta	SL	7.4	2.28	1.00	1.29	0.083	0.010
R 6	Matkota	S	7.4	2.14	1.25	1.66	0.061	0.016
R 7	Rudrapur	SCL	7.1	2.55	1.25	1.39	0.098	0.250
R 8	Rudrapur	SL	7.6	2.55	3.00	2.03	0.041	0.060
R 9	Kichha	SCL	7.5	1.47	1.00	1.94	0.142	0.012
R 10	Kichha	SCL	7.2	1.47	1.00	1.48	0.119	0.239
R 11	Dabhaura	SCL	7.8	2.11	3.25	..	0.107	..
R 12	Dabhaura	S	7.4	1.84	2.75	..	0.070	..
R 13	Dabhaura	SL	7.2	2.29	1.75	1.20	0.035	0.039
R 14	Sarbarkhera	SCL	7.5	1.21	2.00	0.63	0.048	0.049
R 15	Lakshmanpurpatti	S	8.0	1.34	1.25	1.29	0.022	0.010
R 16	Phattipurwa	SL	7.2	1.21	0.75	1.11	0.090	0.260
R 17	Kashipur	SL	7.0	1.07	0.75	2.40	0.101	0.187
R 18	Kashipur	SL	8.4	2.01	2.00	1.57	0.051	0.060
		Bhabhar soils (Nainital district)						
H 1	Haldwani	SL	6.6	1.43	0.61	0.82	0.235	0.077
H 2	Haldwani	SL	6.6	1.60	0.61	0.80	0.212	0.071
H 3	Haldwani	SL	6.6	1.37	0.50	0.43	0.246	0.032
H 4	Kishanpur	LS	6.5	2.29	0.49	0.66	0.126	0.086
H 5	Haripur	LS	6.8	2.55	1.24	0,15	0.258	0.016
H 6	Haripur	SL	6.7	2.55	0.74	1.02	0.132	0.114
H 7	Fatehpur	LS	6.9	1.60	0.49	1.01	0.124	0.018
H 8	Fatehpur	SL	6.5	2.91	0.36	0.99	0.136	0.152
H 9	Fatehpur	SL	6.6	2.16	0.64	0.49	0.124	0.106
H 10	Lamachaur	S	6.7	2.39	0.74	0.45	0.132	0.136

Table 1—(*Contd.*)

1	2	3	4	5	6	7	8	9
H 11	Lamachaur	SL	6.5	2.88	0.99	0.56	0.086	0.136
H 12	Lamachaur	SL	6.5	2.59	0.86	0.56	0.130	0.142
H 13	Halduchaur	LS	6.3	3.05	0.86	1.17	0.084	0.121
H 14	Lalkua	SL	6.7	2.26	0.73	0.90	0.151	0.204
H 15	Lalkua	SL	6.4	2.65	0.75	0.57	0.132	0.144
H 16	Lalkua	SL	6.3	3.00	0.99	0.68	0.131	0.128
		Vindhyan soils (Varanasi and Mirzapur districts)						
M 1	Naugarh, Varanasi	SL	6.1	1.01	0.31	0.35	0.122	0.007
M 2	Lauri, Varanasi	LS	6.0	1.57	0.43	0.33	0.098	0.006
M 3	Kotwa, Mirzapur	LS	6.1	1.53	0.56	0.89	0.037	0.008
M 4	Kotwa, Mirzapur	SL	6.4	1.11	0.56	0.52	0.132	0.115
M 5	Marihan, Mirzapur	SL	5.9	1.43	1.06	0.53	0.044	0.004
M 6	Marihan, Mirzapur	SL	6.3	1.27	0.43	0.22	0.139	0.031
M 7	Ghorwal, Mirzapur	SL	6.9	1.24	1.67	0.74	0.125	0.029
M 8	Saktesgarh, Mirzapur	SL	6.3	1.34	0.93	0.49	0.057	0.007
M 9	Do	SL	6.4	1.24	0.86	0.56	0.057	0.005
M 10	Robertsganj, Mirzapur	SCL	6.9	1.86	2.67	0.71	0.023	0.005
M 11	Do	SL	6.9	2.26	1.42	0.65	0.014	0.004
M 12	Do	CL	7.0	1.07	0.72	0.40	0.054	0.025
M 13	Lalganj, Mirzapur	CL	7.1	1.83	2.18	0.57	0.023	0.033
M 14	Do	SL	7.2	1.86	1.92	0.64	0.063	0.021
		Karail soils (Mirzapur district)						
M 15	Tisuhi, Mirzapur	CL	6.4	1.21	1.43	0.53	0.023	0.005
M 16	Khairahi, Mirzapur	CL	6.9	1.34	3.06	0.44	0.008	0.004
M 17	Khairahi, Mirzapur	CL	6.9	2.79	4.04	0.51	0.096	0.021
M 18	Robertsganj, Mirzapur	SCL	7.2	2.26	4.41	0.62	0.041	0.041
		Bundelkhand type 1B (Rakar) soils (Jhansi district)						
J 1	Bansi	S	6.7	0.75	0.68	0.76	0.071	0.064
J 2	Nayagaon	S	6.9	0.62	0.56	0.57	0.083	0.054
J 3	Raksa	LS	6.6	1.34	0.42	0.61	0.110	0.047
J 4	Dailey	SL	6.7	0.84	0.43	0.77	0.089	0.016
J 5	Bharari	SL	6.6	1.74	0.43	0.78	0.127	0.161

Table 1—(*Contd.*)

1	2	3	4	5	6	7	8	9
		Bundelkhand Type II—(Parwa) soils (Jhansi district)						
J 6	Bansi	SCL	7.2	2.63	1.53	1.02	0.008	0.003
J 7	Bansi	SL	6.5	1.74	1.33	0.65	0.015	0.003
J 8	Lalitpur	SL	7.5	2.50	2.67	1.29	0.041	0.006
J 9	Lalitpur	SL	6.9	1.25	1.18	0.99	0.060	0.008
J 10	Lalitpur	SL	7.2	1.15	1.56	0.93	0.028	0.003
J 11	Bharari	SL	7.0	1.71	1.55	0.85	0.041	0.008
J 12	Chirgaon	SL	7.1	1.81	1.44	1.02	0.051	0.015
J 13	Chirgaon	SCL	6.5	1.61	1.42	0.86	0.037	0.006
J 14	Mauranipur	SL	7.2	0.91	1.91	1.02	0.037	0.009
J 15	Mauranipur	SL	7.1	1.21	5.92	0.57	0.014	0.002
		Arid Alluvial soils (Lucknow district)						
L 1	Chinhat	SL	6.9	0.56	0.78	0.74	0.051	0.408
L 2	Kamta	SL	6.8	1.15	0.53	1.36	0.035	00.90
L 3	Ismailganj	SL	7.0	1.34	1.21	1.02	0.024	0.021
L 4	Kukrail	SL	7.1	0.62	1.08	0.58	0.031	0.030
L 5	Bakshi Talab	SCL	7.1	1.47	3.54	0.82	0.011	0.275
L 6	Raipur	SL	7.1	0.16	0.47	0.74	0.014	0.022
L 7	Madiaon	LS	7.2	0.68	0.76	0.71	0.024	0.024
L 8	Ahibannapur	SCL	7.0	1.67	1.45	0.93	0·014	0.068
L 9	Atrauli	SL	7.2	1.63	7.07	1.09	0.105	0.045
L 10	Gudamba	L	7.3	0.58	1.03	1.28	0.047	0.096
L 11	Gannepurwa	SL	7.4	1.61	2.31	1.78	0.071	0.034
L 12	Chandganj	SL	7.2	0.63	1.25	1.03	0.070	0.076
L 13	Naubasta	SL	6.7	1.07	0.72	0.99	0.061	0.046
L 14	Sikrauli	SL	7.2	1.41	1.28	0.93	0.198	0.027
L 15	Chandaiya	SL	7.1	0.56	1.06	1.20	0.254	0.029
L 16	Balaganj	SCL	7.3	0.62	13.18	1.05	0.057	0.102
L 17	Nishatganj	SL	7.2	0.46	0.96	1.08	0.088	0.023
L 18	Nishatganj	SCL	7.1	0.69	1.46	1.62	0.113	0.040
L 19	Lilmatha	CL	7.5	0.69	5.69	0.62	0.061	0.029
L 20	Badshabagh	LS	6.7	0.83	0.72	0.45	0.082	0.027

Table 1—(*Contd.*)

1	2	3	4	5	6	7	8	9
		Semi-desert Alluvial soils (Agra and Mathura districts)						
A 1	Masani	S	7.9	0.37	0.75	1.14	0.022	0.009
A 2	Brindaban	SCL	8.2	1.41	1.00	0.525	0.077	0.045
A 3	Brindaban	SL	8.4	1.47	1.00	0.15	0.083	0.017
A 4	Chhata	SCL	7.9	1.04	1.50	1.14	0.109	0.010
A 5	Chhata	SCL	7.2	0.87	1.00	1.81	0.095	0.010
A 6	Raya	SCL	8.0	1.08	1.25	0.44	0.095	0.012
A 7	Raya	SL	7.3	0.77	1.00	1.21	0.114	0.014
A 8	Fatehpur Sikri	SL	8.4	1.44	1.00	0.78	0.168	0.029
A 9	Fatehpur Sikri	SL	8.5	1.47	2.75	0.79	0.084	0.034
A 10	Fatehpur Sikri	SL	8.2	1.41	1.25	0.62	0.108	0.018
A 11	Saiyan	S	8.3	1.11	1.00	0.69	0.012	0.026
A 12	Saiyan	LS	8.1	0.77	1.25	1.05	0.047	0.057
A 13	Jagner	SL	8.3	0.77	1.00	2.00	0.107	0.030
A 14	Jagner	LS	8.2	1.08	1.25	0.67	0.053	0.011
A 15	Kagarol	L	8.3	2.98	2.00	2.67	0.120	0.048
A 16	Tantpur	SL	7.5	2.98	1.25	0.74	0.012	0.025
A 17	Tantpur	SL	7.5	0.90	0.75	1.24	0 065	0.077
A 18	Tantpur	S	7.5	1.37	0.75	0.95	0.084	0.010

Bhabhar soils in pot culture failed to respond significantly to foliar application of molybdenum (Text-fig. 1).

Compared to Bhabhar soils, the Tarai soils showed relatively low values of available molybdenum. Out of the eighteen samples representing this type, four fell in the deficiency range on the basis of bioassay and seven on the basis of Amm. oxalate-oxalic acid extraction.

Vindhyan and Karail soils from Districts Varanasi and Mirzapur were also found to be low in molybdenum. Available molybdenum in Vindhyan soils ranged 0.014 to 0.139 ppm as extracted with Amm. oxalate-oxalic acid and 0.004 to 0.116 ppm as determined by the bioassay test. The corresponding values for the Karail soils were 0.008 to 0.096 ppm, and 0.004 to 0.041 ppm. Both Amm. oxalate-oxalic acid extraction and bioassay revealed molybdenum deficiency in four out of the five Karail soils examined. In Vindhyan soils bioassay suggested deficiency of available molybdenum in a larger proportion of soils (about 80 %) than Amm. oxalate-oxalic acid extraction (35 %).

On the basis of soil tests, Bundelkhand type IB (Rakar) soils were found to be largely sufficient in molybdenum. Bioassay revealed molybdenum deficiency in only one out of the five soils and Amm. oxalate-oxalic acid extraction in none. But, contrary to expectations, cauliflower plants grown on four out of five Rakar soils in pot culture showed a

significant response to molybdenum application. Even though they had the same parent material as the type IB (Rakar) soils, the type II (Parwa) soils were found to be low in molybdenum on the basis of both soil tests and crop response. In the Parwa soils, Amm. oxalate-oxalic acid extractable molybdenum ranged between 0.008 to 0.060 ppm and bioassayed molybdenum ranged between 0.002 to 0.015 ppm, all the ten samples examined indicating molybdenum deficiency. Also, in consonance with the soil tests for available molybdenum, cauliflower plants grown on four out of the five Bundelkhand type II (Parwa) soils in pot culture showed a significant increase in yield by foliar application of molybdenum (Text-fig. 1). Our observations with respect to Bundelkhand soils, particularly the Parwa soils, are not in agreement with PATHAK, SHANKAR AND MISRA (1968) who reported these soils to be sufficient in molybdenum.

Alluvial soils were in general low in available molybdenum. In the semi-desert Alluvial soils of Agra and Mathura Districts Amm. oxalate-oxalic acid extractable molybdenum ranged from 0.012 to 0.168 ppm (average 0.081 ppm), with four out of the eighteen soils lying in the deficiency range. Compared to Amm. oxalate-oxalic acid extraction, bioassay with *Aspergillus niger* revealed molybdenum deficiency in a larger proportion of soils. Available molybdenum values using the bioassay method ranged between 0.009 and 0.077 ppm revealing molybdenum deficiency in twelve out of the eighteen samples tested. In the arid Alluvial soils of Lucknow District, Amm. oxalate-oxalic acid extractable molybdenum ranged between 0.011 to 0.254 ppm and bioassayed molybdenum from 0.022 to 0.408 ppm with about 40 per cent samples analysed by both the methods falling in the deficiency range. But in none of the six Alluvial soils from Lucknow, wherein response to molybdenum application was tried, was any significant response observed as a result of molybdenum application.

In Bundelkhand, Tarai and Vindhyan soils, the two methods of determining soil available molybdenum—Amm. oxalate-oxalic acid, pH 3.3, extraction and bioassay—showed positive correlation, significant at P=0.01 in case of Bundelkhand soils ($r=+0.79$) and at P=0.05 in case of Tarai ($r=0.51$) and Vindhyan ($r=+0.48$) soils. In Bhabhar and Alluvial soils both from arid and semi-desert regions the available molybdenum values as determined by the two methods were not positively correlated. This, along with the fact that there was a poor correlation between soil test and crop response to molybdenum application in Rakar soils of Jhansi and arid Alluvial soils of Lucknow, would suggest that there is need for revaluation of the critical limits for available molybdenum in these soils using the Grigg's extractant and the bioassay method.

Within the range encountered here, available molybdenum as determined by either of the two methods of soil extraction used here was not related to pH, calcium carbonate and organic matter content of soils and in neither of the cases was the correlation between available molybdenum and the above soil characteristics found to be statistically significant.

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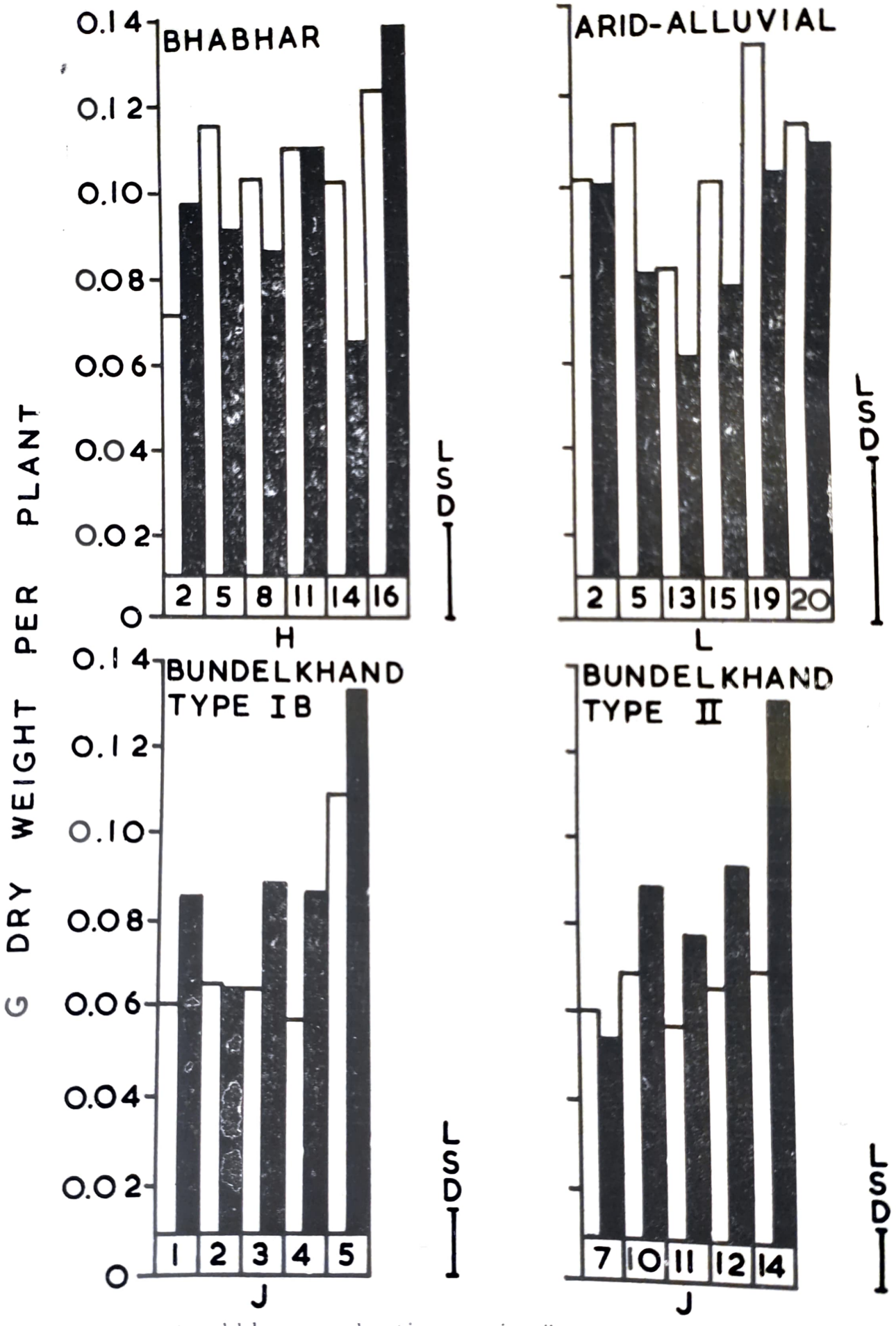

Text-fig. 1 Response to molybdenum amendment in some major soil types of U.P.

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