Available Macro Nutrient Status and their Relationship with Soil Physico-Chemical Properties of Sri Ganganagar District of Rajasthan, India

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Soil fertility evaluation of an area is an important aspect in context of sustainable agriculture production. The macro nutrients govern the fertility of soils and control the growth and yields of crops. In the present investigation Raisingh Nagar block was selected in the district Sri Ganganagar of Rajasthan and studied the available macronutrient status and their relationship with physico-chemical properties. Sri Ganganagar district have different cropping systems and irrigated by Ganga canal and Bhakhra canal tributaries. Twenty seven representative villages were chosen and four surface soil (0-15 cm) samples collected from each village and analysed for physico-chemical properties and available N, P, K, S, exchangeable Ca and Mg status using standard laboratory procedures. Results of the study indicated that soils of Raisingh Nagar block were low to medium in organic carbon. Out of 108 collected soil samples, 97% were medium in available nitrogen and medium to high in available phosphorus, potassium and sulphur, however, available Ca and Mg found sufficient.

Key words: Macronutrient, Physico-chemical properties, Correlation, Sri Ganganagar.

In developing countries like India, where land-person ratio is rapidly narrowing, the only means of meeting the needs of agricultural produce is through increased productivity without detriment to environment and sustainability. Soil characterization in relation to evaluation of fertility status of soils of an area is an important context of sustainable agriculture production. Nitrogen, phosphorus, potassium, sulphur, calcium and magnesium are important soil nutrients which control the fertility and yield of the crops. Because of imbalanced and inadequate fertilizer use coupled with low efficiency of other inputs, the response efficiency of chemical fertilizer nutrients has declined tremendously under intensive agriculture in recent years. Variation in nutrient supply is natural phenomenon and some of them may be sufficient where others may be deficient. According to Lal and Singh, soil quality degradation process with reference to productivity or fertility encompasses physical, chemical and biological degradation process[1]. This is pre-requisite for determining appropriate conservation activities in monitoring our natural resource base. With the advances in information technology the data on soils, weather and other data can be integrated in making such decisions[2]. The stagnation in crop productivity cannot be boosted without judicious

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use of macro and micronutrient fertilizers to overcome existing imbalances or deficiencies.

Rajasthan, the largest State in the country in terms of geographical area, is located in the north-western part of the country. It has a geographical area of 342239 square kilometer, which constitute 10.41% area of the country and 5.67% of national population (Census, 2012 Provisional data). The prospects of agriculture in the State largely depend on timely arrival of monsoon. Where rainfall pattern indicates that during the current monsoon season, the State has received 732.82 mm rainfall against the normal rainfall of 418.7 mm. About 61% area lies in arid and semi-arid tracts, where soils are having poor fertility, low water holding capacity, high infiltration rate and shallow in depth in some areas[3]. One million hectare area is under problematic soils (saline and alkaline). Due to scarcity of rainfall there is limited availability of ground water. The crops suffer due to high temperature and wind velocity. The water holding capacity is inadequate in lighter soils. The nitrogen and organic carbon status of the soils, in general is medium[4]. The soils are well supplied with potassium. Micro elemental deficiencies particularly zinc and sulphur has also been observed in pockets.

Present investigation was useful in judging the deficiency of various nutrients and thereby use of fertilizers depending on their status. The present study was conducted to recognize the status of macronutrient and their correlation with physico-chemical properties in the soils of Raisingh Nagar block district Sri Ganganagar.

MATERIALS AND METHODS

Study area

Sri Ganganagar is a northern most district of Rajasthan state in Western India (Fig. 1). The town of Sri Ganganagar is the district headquarters and located between latitude 29° 14' 9.03" to 29° 44' 3.39" and longitude 73° 7' 37.64" to 73° 41' 13.47". Sri Ganganagar is situated at the point where the Sutlej waters enter Rajasthan. Raisingh Nagar is one of the nine tehsil of Sri Ganganagar district, located in central-western area. The climate of Raisingh Nagar is marked by with large variation of temperature, extreme dryness and scanty rainfall, where mean monthly maximum temperature during summer months (May to July) reaches up to 50°C and minimum temperature during winter months (December and January) sometimes goes as low as 0°C or even less. Mean annual rainfall is 254 mm with a coefficient of variation of 50% and probable maximum precipitation of 45 cm. The mean annual potential evapo-transpiration is about 1650 mm. The region is irrigated by the Ganga canal and the Bhakhra canal tributaries. The northern region, which is 3/4 of the district, resembles the fertile plains of Punjab, but some areas, like the area between the towns of Raisingh Nagar and Vijay Nagar, have desert like conditions. Major crops (Table 1) of the region are wheat, cotton, mustard, guar, grams, bajra, barely and sugarcane. Horticulture is also becoming popular among farmers. Kinnow (a citrus family fruit) is a popular horticultural crop and other fruits of the citrus family are also grown. Industries in Sri Ganganagar district are based on agriculture.

Soil sampling and analysis

Surface soil of the farmer's field from different villages of Raisingh Nagar block of Sri Ganganagar district, were sampled randomly to a depth of 0-15 cm in V shape with the help of *Khurpi*. Each soil sample was mixed thoroughly and about a half kilogram of composite sample from farmer's fields was analyzed. The physical properties of soil *viz*. bulk density by core method, particle density by pycnometer method[5] and water holding capacity was measured following the procedure of Klute and Dirksen[6].

Soil pH and electrical conductivity (EC) of the soil samples in soil: water suspension (1:2.5) was measured using a glass electrode in a digital pH meter and systronics electrical conductivity meter, respectively[7]. Organic carbon was determined by wet digestion method of Walkley and Black[8], available N by Alkaline permanganate method[9], Available P by colorimetric method using sodium bicarbonate[10], Available K by ammonium acetate extraction method[11], Available S by turbidimetric method[12] and exchangeable Ca, and Mg by complexometric titration method[13].

Statistical analysis

The relationship between different soil characteristics and macronutrient contents in soils were determined using correlation coefficients formula:

$$r = \sqrt{\frac{SP(xy)}{SS(x),\ SS(y)}}$$

Where:
r = Correlation coefficient
SP (xy) = Sum product of x, y variables
SS (x) = Sum of square of x variable
SS (y) = Sum of square of y variable

RESULTS AND DISCUSSION

Physico-chemical properties of Soil

The data on pH, EC, B.D., P.D., W.H.C. and organic carbon are presented in Table 2 which revealed that the pH of soils ranged varies 7.1 to 8.8, with average value of 7.84. Absence of luxuriant vegetation further decreases level of organic matter in these soils. It is expected that a decrease in rainfall or Increase in aridity increases the pH due to precipitation of $CaCO_3$ and also increases soil pH. The soils of Raisingh Nagar block were neutral to moderately alkaline in reaction. This might be due to medium to high base saturation of soils. Kumar and Babel; Sharma *et al.* and Nigam *et al.* also recorded similar findings[14, 15, 16].

The electrical conductivity of Raisingh Nagar block (Table 2) varied from 0.10 to 1.40 dS m^{-1} with an average value of 0.49 dS m^{-1}. The values indicated that salinity is not a problem in these soils. Similar result was observed by Yadav; Sharma *et al.* and Kumar and Babel [17, 14, 15].

Bulk density and Particle density ranged from 1.03 to 1.74 and 1.67 to 2.63 Mg m^{-3} respectively with a mean value of 1.30 and 2.25 Mg

Table 1. Description of sampling sites

S.N.	Village Name	Cropping pattern
1.	29 N.P.	Clusterbean-Mustard, Clusterbean-Wheat, Cotton-Wheat, Bajra-Gram
2.	84 R.B.(A)	Fallow-Mustard, Sorghum-Barley, Moong-Mustard, Cotton-Wheat
3.	2M.K.	Clusterbean-Oat, Til-Gram, Bajra-Gram, Rice-Wheat
4.	Thakri	Moong-Mustard, Cotton-Wheat, Cotton-Gram, Clusterbean-Wheat
5.	4 M.K.	Bajra-Gram, Moong-Mustard, Wheat-Cotton, Clusterbean-Mustard
6.	3 M.K.	Fallow-Sugarcane, Fallow-Sugarcane, Cotton-Wheat, Bajra-Wheat
7.	Muklawa	Sorghum-Gram, Moong-Mustard, Clusterbean-Wheat, Rice-Wheat
8.	84 R.B.(B)	Bajra-Gram, Fallow-Mustard, Cotton-Wheat, Sorghum-Wheat
9.	10T.K.	Moong-Oat, Til-Gram, Clusterbean-Mustard, Cluterbean-Wheat
10.	6 M.K.	Cotton-Wheat, Fallow-Sugarcane, Rice-Wheat, Bajra-Gram
11.	17 P.S. (Pavarsar miner)	Fallow-Mustard, Clusterbean-Wheat, Cotton-Wheat, Moong-Mustard
12.	50 R.B.	Cotton-Wheat, Fallow-Mustard, Cotton-Wheat, Moong-Mustard
13.	14 T.K.	Cotton-Wheat, Fallow-Sugarcane, Clusterbean-Wheat, Moong-Wheat
14.	Jagatsinghwala	Bajra-Wheat, Sorghum-Oat, Cotton-Wheat, Fallow-Mustard
15.	Varawali	Fallow-Mustard, Clusterbean-Wheat, Fallow-Sugarcane, Sorghum-Berseem
16.	32 M.L.(miner lift)	Cotton-Wheat, Rice-Wheat, Rice-Wheat, Clusterbean-Mustard
17.	28 M.L.(Miner lift)	Clusterbean-Wheat, Moong-Mustard, Clusterbean-Mustard-Moong, Cotton-Wheat
18.	Udsar	Bajra-Barley, Fallow-Mustard, Sorghum-Berseem, Clusterbean-Wheat
19.	16 P.S. (Pavarsar miner)	Cotton-Mustard, Cotton-Wheat, Clusterbean-Gram, Fallow-Mustard
20.	14 P.S. (Pavarsar miner)	Cotton-Wheat, Clusterbean-Wheat, Moong-Mustard, Sorghum-Berseem
21.	Ganguwala	Bajra-Gram, Cotton-Wheat, Clusterbean-Mustard, Clusterbean-Wheat
22.	Kardawali	Moong-Gram, Fallow-Mustard, Clusterbean-Mustard, Clusterbean-Wheat
23.	31 M.L.(Miner lift)	Moong- Mustard, Clusterbean-Wheat, Clusterbean-Mustard, Fallow-Mustard
24.	15P.S. (Pavarsar miner)	Fallow-Mustard, Cotton-Wheat, Clusterbean –Mustard, Moong-Gram
25.	7 N.P.	Fallow-Mustard, Clusterbean-Wheat, Clusterbean-Mustard, Clusterbean-Gram
26.	Dabla	Moong-Mustard, Fallow-Mustard, Clusterbean-Mustard, Fallow-Mustard
27.	33 M.L.(Miner lift)	Cotton-Wheat, Clusterbean-Mustard, Til-Barley, Clusterbean-Wheat

m^{-3}. These results are confirmatory with results obtained by Pranagal and Chmielewska in soils of South-Eastern Poland[18].

Water holding capacity of soil ranged between 22.10 to 83.15%, with a mean value of 41.69%. Water holding capacity found low compared to other soils may be due to low organic matter and clay content.

Estimates of organic carbon are used to assess the amount of organic matter in soils. Soil organic matter content can be used as an index of N availability because the N content in soil organic matter is relatively constant. The data on percent organic carbon content ranged between 0.13 to 0.61 percent with a mean value of 0.29 percent (Table 2), Thus majority of the soil samples of Raisingh Nagar block were low in their organic matter status. The high temperatures prevailing in the area might be responsible for rapid decomposition of organic matter. These findings are in agreement with the results reported by Sharma *et al.* in soils under continuous vegetable based cropping systems at Indian Institute of Vegetable Research, Varanasi[15].

Status of Available Primary Macronutrients in Soil

The status of N, P and K has been shown in Tables 3, 4 and 5. Available nitrogen content of these soils ranged between 100.35 to 326.14 kg ha^{-1} with a mean value of 202.79 kg/ha. On the basis of the ratings suggested by Muhr *et al.*[19], 3% of the soil samples were found to be low (< 280 kg N ha^{-1}) and remaining 97 % in the category of medium (280 to 560 kg N ha^{-1}) (Table 5). Most of the sample was shown the medium availability of nitrogen. The availability of nitrogen is not only an essential part of carbohydrates, fats and oils but also an essential ingredient of proteins. The available nitrogen is an important factor to increase the soil fertility. Low nitrogen status in the soils could be due to low amount of organic carbon in the soils and uncertain rainfall has a major impact on availability of nitrogen. Similar results were observed by Verma *et al*.[20].

The available phosphorous content in these soils varied from 0.15 to 32 kg ha^{-1} with a mean value of 25.59 kg ha^{-1}, On the basis of the

Table 2. Physico-chemical properties of soils of Raisingh Nagar block

Soil characteristics	Range	Mean	S.D.
Moisture (%)	12.5-69.69	30.55	9.97
pH (1:2.5)	7.1-8.8	7.84	0.46
E.C.(dS m^{-1})	0.10-1.40	0.49	0.24
B.D.(Mg^{-3})	1.03-1.74	1.30	0.085
P.D.(Mg^{-3})	1.67-2.63	2.25	0.17
W.H.C. (%)	22.10-83.15	41.69	10.23
O.C. (%)	0.13-0.61	0.29	0.11

Table 3. Status of available macronutrients viz. available N, P, K, S, Exchangeable Ca and Mg in soils of Raisingh Nagar block

Soil characteristics	Range	Mean	S.D.
Available N (kg ha^{-1})	100.35-326.14	202.79	46.48
Available P (kg ha^{-1})	0.15-32	25.59	4.71
Available K (kg ha^{-1})	290-482	367.57	50.48
Available S (kg ha^{-1})	12.8-30.5	22.43	5.12
Exchangeable Ca (Cmol(P^+) Kg^{-1})	0.4-10.2	5.92	2.54
Exchangeable Mg (Cmol(P^+) kg^{-1})	0.5-8.6	4.11	2.47

Table 4. Rating limits for soil test values used in India (Muhr *et al.*, 1965)

Nutrients	Rating of the soil test values		
	Low	Medium	High
Organic carbon (%)	< 0.5	0.5 – 0.75	> 0.75
Available N(kg/ha)	<280	280 – 560	>560
Available P (kg/ha)	<12.5	12.5 – 25	>25
Available K (kg/ha)	<135	135 – 335	>335
Available S (kg/ha)	<10	10-20	>20
	Deficient	Sufficient	
Calcium (Cmol (p^+) kg^{-1})	<1.5	>1.5	-
Magnesium (Cmol (p^+) kg^{-1})	<1	>1	-

limits suggested to Muhr *et al.*[19], most of the soil samples (37%) were medium (12.5 to 25 kg P ha^{-1}) in available phosphorus status and 63% were under high (>25 kg P ha^{-1}) category. It is a constituent of the cell nucleus, essential for cell division and the development of meristematic tissues at the growing points. It makes 0.1 to 0.5% of dry weight of the plant. According to Gupta *et al.* the normal value of phosphorus in soil should be (12.5 to 25 kg ha^{-1})[21]. Higher P may be due to fixed phosphorus pool of phosphate contains inorganic phosphate compounds that are very insoluble and organic compounds that are resistant to mineralization by microorganisms in soil. These findings are in agreement with the results reported by Meena *et al*. in soil of Tonk district of Rajasthan[22].

Status of available potassium content in these soils ranged from 290 to 482 kg ha^{-1} with a mean value of 367.57 kg ha^{-1}. According to Muhr *et al*.[19], Out of 108 soil samples, 37% soil samples were found under medium (135 to 335 kg K ha^{-1}) range and 63% soil samples under high (>335 kg K ha^{-1}) available potassium. The higher value of K content indicates the presence of micaceous parent minerals. Pulakeshi *et al*.[23] observed similar results from soils in Mantagani village of North Karnataka.

Status of Available Secondary Macronutrients

The data on status of available S, exchangeable Ca^{2+} and Mg^{2+} in soils of Raisingh Nagar block of Sri Ganganagar district are presented in Tables 3, 4 and 5. The available sulphur content in soils of Raisingh Nagar block ranged from 12.8 to 30.5 kg ha^{-1} with an average value of 22.43 kg ha^{-1}. Plant roots absorb sulphur in the form of SO_4^{-2} from the soil solution. Keeping this fact in view, the soil under study may be classified as deficient (<10 kg S ha^{-1}), medium (10-20 kg S ha^{-1}) and sufficient (>20 kg S ha^{-1}) category as per the categorization given by Muhr *et al.*[19]. According to these categories, 44% samples were found under medium and remaining 56% samples were found under high category. Thus, the soils of Raisingh Nagar block of district Sri Ganganagar are likely to well respond to sulphur fertilization. High available sulphur in these soils is due to sulphur bearing

Table 5. Classification OC% and available Macro nutrients status content in soils of Raisingh Nagar block

S. No.	Elements	No. of samples	% of samples	No. of samples	% of samples	No. of samples	% of samples
		Low		Medium		High	
1	OC	96	89	12	11	0	0
2	N	4	3	104	97	0	0
3	P	0	0	40	37	68	63
4	K	0	0	40	37	68	63
5	S	0	0	48	44	60	56
		Deficient	Sufficient				
6	Ca	8	7	100	93	-	-
7	Mg	16	15	92	85	-	-

Table 6. Correlation between physico-chemical properties and available macro nutrients in the soil of Raisingh Nagar

	N	P	K	S	Ca	Mg
pH	0.288**	0.069	-0.037	0.341*	0.061	0.122
EC	0.0001	-0.098	0.178	-0.010	-0.250**	-0.179
OC	0.069*	-0.219*	0.307**	0.099	0.122	0.123
BD	0.071	-0.140	0.151	0.140	-0.103	-0.080
PD	-0.155*	0.021	-0.176	-0.046	0.082	0.038
WHC	-0.043	-0.282**	0.123	0.070	-0.124	-0.111

* Significant at 5%, ** Significant at 1%

minerals. These results are comparable with those reported by Giri *et al.*[24]and Singh and Mishra[25].

The data in Tables 3, 4 and 5 revealed that the exchangeable calcium content of these soils ranged from 0.4 to 10.2 cmol (p^+) kg^{-1} with an average value of 5.9 cmol (p^+) kg^{-1}. About 93% soil samples were found sufficient in exchangeable calcium, while 7.40% soil samples were found deficient in exchangeable calcium. It may be due to accumulation of calcium on surface soil by high evaporation, presence of high amount of $CaCO_3$ and continuous use of various fertilizer nutrient sources that influences the exchangeable bases ratios. These findings are in agreement with the result reported by Sharma *et al.* and Salami and Sangoyomi in soils of west Nigeria[15, 26]. Further, data showed that the exchangeable Mg^{2+} content in soils of Raisingh Nagar block varied from 0.5 to 8.6 cmol (p^+) kg^{-1} with a mean value of 4.11 cmol (p^+) kg^{-1}. Out of 108 soil samples, 14.81% soil samples were found deficient and 85.18 % soil samples were found sufficient in available Mg^{2+}. The sufficient magnesium may be attributed to low rainfall, favours least leaching of magnesium. Similar trend was recorded by Sharma *et al.*[15].

Correlation between physico-chemical properties and available macro nutrients in the soils of Raisingh Nagar

The data on correlation between soil properties and available nutrients in top soil of Raisingh Nagar block are presented in Table 6 revealed the soil pH (r= 0.288**) and organic carbon (r= 0.069*) was positively correlated with available nitrogen and comparable with the relationship reported by Somasundaram *et al.*[27] and Kartikeyan *et al.*[28]. However, bulk density and EC has not significant relationship with nitrogen. Available N decreases with decrease in water holding capacity. This may be due to low organic matter, clay content and scanty rainfall. Particle density and water holding capacity showed negative correlation with nitrogen.

Available phosphorus had significantly negative correlation with organic carbon (r=0.219*)

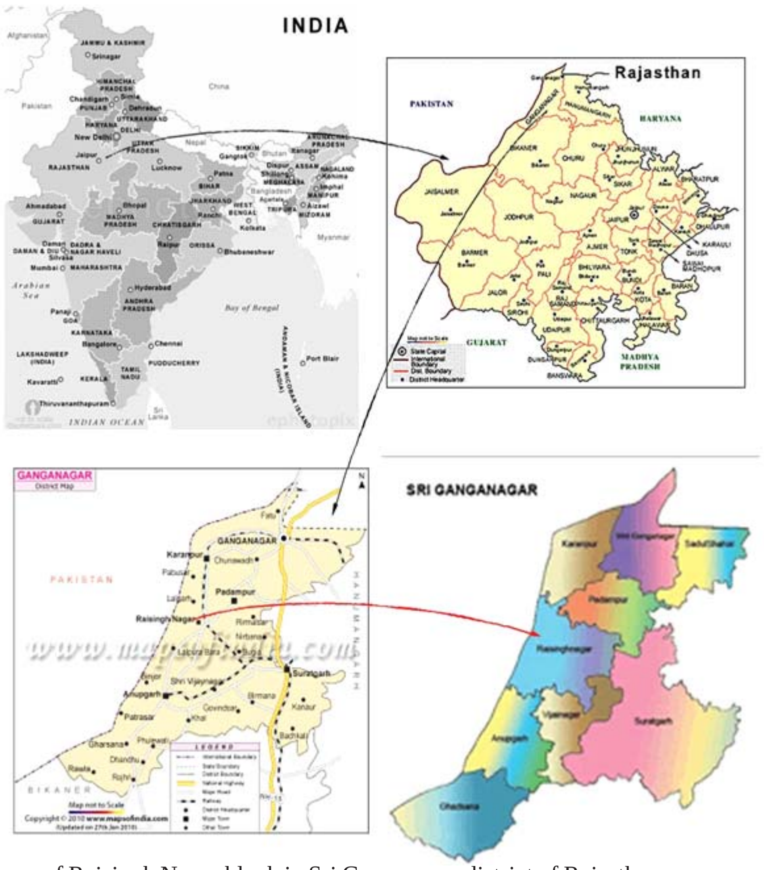

Fig. 1. Location map of Raisingh Nagar block in Sri Ganganagar district of Rajasthan

and water holding capacity (r= -0.282**). Eelectrical conductivity (r= -0.098) and bulk density (r= -0.140) has negatively non-significant correlation with phosphorus. This indicates that absence of organic matter decreases the availability of phosphorus. The relationship between available P and C level could not exhibit the concurrent results. Jatav and Mishra have also reported the similar results in soil of Mewar region of Rajasthan and Janjgir district of Chhattisgarh[29].

A significant and positive correlation (r= 0.307**) was found between available K and organic carbon. This might be due to creation of favourable environment with presence of organic matter. Available K show non-significant negative relationship with pH (r= -0.37), particle density (r= 0.021) and non-significant relationship with EC, bulk density and water holding capacity. Similar relationship was also noticed by Chauhan[30].

Available sulphur in these soil show significant relationship with pH (r= 0.341*). Sulphur in these soils show non-significant correlation with organic carbon (r=0.099), bulk density (r= 0.140) water holding capacity (r= 0.070) and negatively non-significant relationship with EC (r= -0.10) and particle density (r= -0.046). These results corroborate the finding of Meena *et al*. positive correlation (r= 0.051) of organic carbon and available sulphur[22]. This relationship was existed because of most of the sulphur is associated with organic matter.

The exchangeable calcium in these soil were non-significant negative correlation with bulk density (r= -0.103) and water holding capacity (r= -0.124). Calcium showed negatively and significant relationship with electrical conductivity (r=-0.250**) and non-significant correlation with pH (r= 0.061), organic carbon (r= 0.122) and particle density (r= 0.082). Bacchewar and Gajbhiya also observed similar results in soils of Latur district of Maharashtra[31].

The exchangeable magnesium in this soil negatively non-significant correlation with EC (r= -0.179), bulk density (r= -0.080) and water holding capacity (r= -0.111). Magnesium in soil had non-significant correlation with pH (r= 0.122), organic carbon (r= 0.123) and particle density (r= 038) and comparable with results reported by Somasundaram *et al*.[27].

CONCLUSION

It can be concluded that the soil from Raisingh Nagar block of Sri Ganganagar district is categorized under neutral to moderately saline and alkaline in reaction. Organic carbon is low in range in the soils of studied area. About, 97% of soil samples found in medium available nitrogen, available phosphorus found medium (37%) to high (67%) and available potassium also recorded in similar range. Among the secondary macronutrient, available S noticed medium (44%) to high (56%) and exchangeable calcium, magnesium found sufficient in range.

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