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Evaluating the nutrient assimilation and nutrient ratios of pulse crops in various yield zones

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Abstract

Plant nutrient analysis is a valuable supplement for soil quality assessment. This research aimed to analyze the nutrient concentration (N,P,K,S) during critical growth stages of pulse crop in the varying yield zones and to compute optimum nutrient ratios required to enhance the productivity in low soil quality zone, to maximize the yield in medium quality zone and to sustain yield in high quality zone. The study was conducted in Virudhunagar district of Tamil Nadu (90°20'72" N 77°20'70"E) during 2016–2018 and the soil properties at preplanting stage (Blackgram var. MDU1) and yield data at maturity stage were recorded. The average yield of 880 kg ha⁻¹ in the high soil quality category was significantly higher than the other two zones which might be due to higher soil available nitrogen and phosphorus that reflected in the highest N and P contents in the crop. The average content of crop K in all the soil quality zones were above the critical value which is attributed to higher soil available K status. The mean sulphur concentration (0.11percent) in the low yielding zone of pulses was less than the critical value (0.2 percent) indicating deficiency status of S. The N/P, N/K and N/S ratios computed in this study 7.0, 1.26 and 11.18 respectively are to be considered as desirable nutrient ratios for obtaining higher yields of pulses and as a basis for conducting further nutrient uptake studies in similar agro climatic regions of the country.

Keywords: nutrient content, nutrient ratios, pulses, variance, yield

Introduction

India is the largest producer of pulses with 29 per cent of global area contributing 19 per cent of the world's pulse production (Singh *et al.*, 2015) ^[11]. In Tamil Nadu, the total area under pulses is 9.5 lakh hectare with a production of 6.5 lakh tonnes. The average productivity of pulses in the state is 712 kg ha⁻¹ (Agricultural statistics at a glance, 2016) ^[1] which is far below the average productivity of the country as well as that of the global productivity. Pulse crops grown with improper nutrient management practices under encounter diversity of constraints broadly on account of poor physical, chemical and biological soil quality and ultimately end up with poor functional capacity (Sharma *et al.*, 2008) ^[12]. The main challenge is to develop soil quality and soil health standards to assess changes which are practical and useful to farmers. Although plant analysis is not a direct evaluation of soil fertility, it is a valuable supplement for soil quality assessment. Analysis of leaf or part of the plants is useful in confirming nutrient deficiencies, toxicities or imbalances, identifying hidden hunger and determining the availability of nutrients in situations when adequate level of a nutrient may be present in the soil, but its availability is constrained due to problems in soil quality such as poor aggregate stability, low soil organic matter content and inadequate amounts of other soil nutrients. (Mir *et al.*, 2013) ^[7]. In spite of the importance of plant nutrient uptake for higher yields, leaf nutrient analysis has not been much widely used so far as a diagnostic tool to complement soil testing in pulse production. Hence, the objective of this study was to determine the nutrient concentrations and to compute desirable nutrient ratios required to enhance the productivity in low soil quality zone, to maximize the yield in medium quality zone and to sustain yield in high quality zone.

Materials and methods

Geographically the study area is located in Virudhunagar district of Tamil Nadu lying at the foot of Western ghats (90°20'72" N 77°20'70"E).

The past decade weather information (2006–2015) revealed that the area has a bimodal rainfall pattern and the mean annual rainfall was 805.5mm. The rainy season covers October to December and maximum rainfall (50%) is received during the months of October, November and December through North East monsoon. Based on the yield documentation of the pulse crop (Blackgram) for the past ten years (Agricultural statistics at a glance, 2016) [1] the sampling area for leaf nutrient analysis and field experiment was divided into three categories viz. low yielding (<400 kg ha⁻¹), medium yielding (400 to 700 kg ha⁻¹) and high yielding (> 700 kg ha⁻¹) which are also indicated as low, medium and high soil quality categories. Blackgram (var. MDU1) was raised in each of the zone during *rabi* 2016-18 adopting similar standard cultivation practices for pulses (agritech.tnau.ac.in, 2016) in all the three categories. About 20 leaf samples from each yield category (20×3 = 60) at two stages namely pre flowering and flowering in such a way that a total of about 120 samples were analyzed. The grain yields were recorded at full maturity stage in each of the category. The total Nitrogen total phosphorus and total sulphur contents in the plant sample was determined as described by Jackson, 1973. The analytical data on plant nutrient concentrations and the leaf blade nutrient ratios (N: P, N: K, N: S, P: K and P: S) were processed with statistical parameters following the methods suggested by Gomez and Gomez (1984) [2]. The soil quality indicators in the low yield category were bulk density (1.44Mgm⁻³), water stable aggregates (38 percent), pH(8.58), EC (0.72 dSm⁻¹), CEC (12.20 cmol (p⁺) kg⁻¹), organic carbon content (1.74 g kg⁻¹), available N,P,K,S status of 138,3.84,168 and 8.51 kg ha⁻¹ and available zinc (0.85 mg kg⁻¹). The corresponding values for medium and high soil quality categories are bulk density (1.31,1.23 Mgm⁻³), water stable aggregates (48,51 percent), pH(8.34,7.52), EC (0.36,0.39 dSm⁻¹), CEC (21.8, 36.9 cmol (p⁺) kg⁻¹), organic carbon content (4.14, 6.60g kg⁻¹), available N (234,282 kg ha⁻¹), P (5.6, 9.1 kg ha⁻¹), K (225,290kg ha⁻¹), S(12.5,15.6 kg ha⁻¹) status and zinc content of 1.51 and 2.07 mg kg⁻¹ respectively.

Results and discussion

The N, P, K and S concentrations of 3rd and 4th leaves of pulse crops assessed during the initial and flowering stages of crop, their mean values and co-efficient of variance in the low, medium and high yielding zones are furnished in Table 1, 2, 3 and 4.

Table 1: Average Nitrogen concentration (percent) of crop from variable yield zones

Crop yield category	Stage of the crop			
	Initial stage	Flowering stage	Mean	CV (%)
Low	1.76	1.25	1.51	8.62
Medium	1.96	1.82	1.89	3.70
High	2.56	2.35	2.46	2.87

Table 2: Average Phosphorus concentrations (percent) of crop from variable yield zones

Pulse yield category	Stage of the crop			
	Initial stage	Flowering stage	Mean	CV (%)
Low	0.16	0.18	0.17	6.23
Medium	0.28	0.24	0.26	4.62
High	0.37	0.32	0.35	2.45

Table 3: Average Potassium concentration (percent) of pulse crop from variable yield zones

Pulse yield category	Stage of the crop			
	Initial stage	Flowering stage	Mean	CV (%)
Low	1.22	1.10	1.16	7.48
Medium	1.86	1.32	1.59	5.66
High	2.14	1.73	1.94	3.77

Table 4: Average Sulphur concentration (percent) of pulse crop from variable yield zones

Pulse yield category	Stage of the crop			
	Initial Stage	Flowering stage	Mean	CV (%)
Low	0.12	0.10	0.11	5.65
Medium	0.16	0.12	0.14	3.82
High	0.25	0.20	0.22	1.46

Crop nutrient concentration

The mean N concentration of 1.81 percent in the low yielding population is below the critical value (Table 5) indicating N deficiency which may lead to a production loss of 10 to 15 percent. (Kokani *et al.* 2015). This deficiency of nitrogen is related to average crop yield of 275 kg ha⁻¹ in the low yielding zone (Table 7). The average yield of 880 kg ha⁻¹ in the high soil quality category is significantly higher than the other two zones which might be due to higher available nitrogen in these soils and is thus reflected in the highest N content of 2.41 percent in the crop.

Sufficient P must be made available in the soil during flowering and pod formation stage for absorption by the crop (Yabigadi *et al.*, 2018) [12]. The highest P concentration (0.37 percent) in high soil quality zone at flowering stage may be attributed to the influence of better soil quality parameters in making the P available to the crop compared to the other two zones. Similar findings have been reported by Yadav *et al.* (2015) [14] while characterizing the effect of phosphorus sources on growth and yield of mungbean.

The average percentage content of K in all the soil quality zones were above the critical value of 1.2 percent which is attributed to higher soil available K status. However, optimum soil quality is essentially needed to maintain favorable physico- chemical environment for adequate supply of K to the crop which is reflected in the highest mean K concentration (1.94 percent) of high yielding zone where significantly higher yield was recorded than the other two zones.

The mean sulphur concentration (0.11percent) in the low yielding zone of pulses was less than the critical value (0.2 percent) indicating deficiency status of S. Regular application of sulphur is not practiced among the pulse growers of the low soil quality zone which is considered as one of the major reasons. These results are in agreement with the findings of Mir *et al.* (2013) [7]. However, the average sulphur concentration of 0.22 percent in the leaf samples of the high soil quality zone reflected in significantly higher yield.

The percentage variance was found to be the highest (8.62 percent) for nitrogen followed by potassium (7.48 percent) in the low yielding zones whereas in the other two zones the CV was comparatively lower for both the nutrients.

Crop nutrient ratios

The average nutrient ratios and their co-efficient of variance (C.V) of the low, medium and high yielding zones are

furnished in Table 6. Nutrient ratios are important tools of interpretation of plant nutrient status as they deal with the nutrient interactions.

The mean N/P, N/K and N/S ratios were the lowest in the high productive zone that resulted in significantly higher yields than the medium and low soil quality categories which recorded correspondingly higher values of these nutrient ratios. The mechanisms contributing to higher yields due to N and P interactions include N induced increased root growth, enhanced root ability to absorb and translocate P and increase in P solubility as a result of decreasing soil pH which accompanies NH_4^+ absorption.

With regard to Nitrogen and Potassium interactions, the effect of N supply on K concentration in the plant is related to the extent of K bioavailability in the root zone. These results are in agreement with the findings of Wilkinson *et al.* (2000). Positive interactions between N and S in plant nutrition are due to the requirement for a balanced supply of these nutrients for efficient protein synthesis (Senthilvalavan and Ravichandran, 2016). The low status of available N and S and organic carbon content in the soil samples analyzed might have lowered the nutrient assimilation resulting in N/S ratio of 22.8 in the low yielding zone compared to that of 16.0 in high productive zone. The CV percent was found to be higher in the ratios involving sulphur *viz.*, N/S and P/S with 21.12 and 17.42 percentages respectively.

Table 5: Critical values and optimum range of nutrient concentration in the leaves of pulse crops (Rajakhwa *et al.*, 2000)

Nutrient	Critical limit (%)	Optimum Range (%)
Nitrogen (N)	2.5	2.25 to 3.0
Phosphorus (P)	0.5	0.25 to 0.30
Potassium (K)	1.2	1.75 to 2.00
Sulphur (S)	0.2	0.20 to 0.25

Table 6: Computation of N/P, N/K, N/S, P/K and P/S crop nutrient ratios

Nutrient ratios	Pulse yielding zones			CV (%)
	Low	Medium	High	
N/P	8.88	7.26	7.00	5.52
N/K	1.30	1.18	1.26	3.28
N/S	13.72	13.50	11.18	15.23
P/K	0.14	0.16	0.18	2.18
P/S	1.54	1.85	1.59	4.92

Table 7: Yield of Blackgram (var. MDU1) as influenced by different soil quality categories

Sample	Yield (kg ha ⁻¹)		
	Low SQ	Medium SQ	High SQ
1	285	622	879
2	368	579	912
3	390	421	784
4	290	721	935
5	306	646	926
6	346	589	935
7	256	477	826
8	154	468	893
9	167	612	973
10	143	498	845
11	372	546	943
12	252	568	832
13	305	413	769
14	167	567	776
15	367	646	945
16	354	705	956
17	289	589	893

18	218	613	823
19	326	516	796
20	278	688	879
21	165	538	976
22	277	443	890
23	328	678	788
24	159	488	989
25	306	588	846
Max	390	721	989
Min	143	413	769
Mean	275	569	880
SD	78	86	92
CV(%)	28.36	15.46	7.72

Conclusions

The soil quality parameters of the high yield zone such as neutral pH, non saline nature, higher cation exchange capacity, moderate amounts of organic matter and higher availability of N, P, K and S might have contributed to the highest assimilation of nutrients and favorable crop nutrient ratios resulting in significantly higher yield of the crops. The N/P, N/K and N/S ratios of 7.0, 1.26 and 11.18 respectively are the desirable nutrient ratios for obtaining higher yields of pulses and can be considered as a basis for conducting further nutrient uptake studies and also for providing suitable scientific management practices to increase the yields of pulses in similar situations of the state and the country.

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