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Water expense and nutrient use efficiency of wheat and winter maize as influenced by integrated nutrient management

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Abstract

A field experiment on integrated nutrient management was initiated in 1980 with 3 levels viz. 0, 50 and 100% of recommended NPK (120, 50, 40 kg ha^{-1}) fertilizers, 10 t ha^{-1} FYM, 13 kg ha^{-1} blue green algae (BGA) applied separately and also in combination under rice-wheat and rice-winter maize cropping sequence. Results of study after the 10th year of cropping indicated that the total water expense and native profile water use by wheat and winter maize crops remained unchanged under different treatments but significantly influenced the water expense efficiency of both the crops. Maximum water expense efficiency of 98.2 and 100.3 kg/ha-cm for wheat and winter maize crops, respectively was recorded under 100% fertilizers combined with FYM + BGA but the nutrient use efficiency was higher at lower levels of fertilizer (50% NPK). Combined use of FYM, BGA or FYM + BGA with fertilizers improved 30 to 45% nutrient use efficiency over the chemical fertilizers alone.

Additional keywords : Soil fertility, water expense efficiency.

Introduction

Irrigation and fertilizers are two major costly inputs in modern agriculture. It is, therefore, essential that the maximum benefit is to be derived by utilizing the every unit of water and fertilizer. Houck (1971) pointed out that efficiency of applied N was 25 to 45% in upland crop and in case of phosphorus it was in the range of 10 to 25%. The efficiency of applied fertilizers and water can be enhanced through balanced and optimum nutrition, tillage, proper water management and source of fertilizer application. The present study was, therefore, undertaken to ascertain the effect of integrated nutrient management on water expense and nutrient use efficiency of wheat and winter maize.

Materials and methods

The field investigation was carried out since 1980 at the experimental farm of Rajendra Agricultural University, Pusa (Bihar) to evaluate the influence of continuous application of NPK fertilizers, farm yard manure (FYM), blue green algae (BGA) on crop production under rice-wheat and rice-winter maize cropping systems. Soil of the experimental field was calcareous silty loam (48.5% sand, 40.5% silt and 11.0% clay) with pH 8.4, EC 0.25 dS m^{-1}, organic carbon 0.49%, free $CaCO_3$ 36.2%, CEC 7.2 cmol (p+) kg^{-1}, ESP 6.5, bulk density 1.53 Mg m^{-3} and steady infiltration rate of 0.8 cm h^{-1}. Application of fertilizers consisted of 0, 50 and 100% of the recommended dose of NPK (120, 50, 40 kgha^{-1}) through urea, single superphosphate, muriate of potash and no FYM/BGA, FYM @10 t ha^{-1} and BGA @13 kg algal crust ha^{-1} separately and in combination (8 treatments). FYM and BGA were applied only during kharif season in rice crop under both the cropping systems.

During the 10th year of cropping, periodic soil water content was monitored in the profile at different stages viz., at the time of sowing, before and after each irrigation and after harvest of the crop at 15 cm depth interval down to 90 cm. Soil moisture content was determined gravimetrically by drying the soil sample in oven at 105°C and then converted to volumetric water content by multiplying mass water content of a particular soil layer with the bulk density of the same layer. The crop water expense was obtained by summing up the amount of effective rainfall received between sowing and harvesting and the differences in volumetric profile water stored between sowing and first irrigation, successive irrigation, last irrigation and harvest. In total 4 and 5 irrigations were given to wheat and winter maize crops, respectively. Water expense efficiency was estimated by dividing the grain yield by the total crop water expense (Prihar *et al.* 1976). Nutrient use efficiency was estimated as described by Parr (1973). Leaf area was measured using electronic leaf area meter (Model : L-300; Licor Ltd., USA). Root length density was measured by line interception method (Newman 1965).

Results and discussion

It is evident from the data (Table 1) that water added through irrigation down to 90 cm depth for different treatments under both the differed marginally by 1 to 3 cm. The total water expense by wheat and winter maize was not significantly influenced due to different treatments. However, slightly higher water expense was found under 50 and 100 NPK fertilizers in combination with FYM + BGA than the control. The values of native profile water use for both the crops remained unchanged under different treatments but winter maize used more profile water than wheat. The water expense efficiency of both the crops was at par for 50 and 100% recommended dose of NPK fertilizers but significantly higher over control. Nakashagir *et al.* (1988) and Bharambe *et al.* (1997) also reported increased water expense efficiency with application of fertilizers. However, continuous application of FYM and BGA either separately or in combination did not show any significant increase in water expense efficiency over the control. Integrated use of FYM, BGA and FYM + BGA with 50 and 100% NPK fertilizers enhanced the water expense efficiency of both the crops. The maximum water expense efficiency of 98.2 and 100.3 kg/ha-cm was recorded by wheat and winter maize crops, respectively at 100% NPK fertilizers combined with FYM + BGA. The leaf area and root growth were also higher in 100% NPK + FYM + BGA treated plot. Verma and Acharya (1996) found a close relationship among leaf area, root growth and water extraction pattern.

Nutrient (NPK) use efficiency (Table 2) in wheat and winter maize was more at lower level than the higher level of fertilizers application. Combined use of FYM, BGA and fertilizers significantly improved the nutrient use efficiency over other treatments. Similar trend was reported by Prasad and Rokima (1991). The positive effect of FYM and BGA on nutrient use efficiency may be due to the reduction in N volatilization loss and P fixation. Greater root proliferation in manured plots might be responsible for greater absorption of nutrients and in turn higher nutrient use efficiency. Potassium utilization efficiency for both

Table 1. Effect of integrated nutrient management on water expense, native profile water use, water expense efficiency, leaf area and root length density in wheat and winter maize

Treatments	Wheat						Winter maize					
	Total water added through irrigation & rainfall* (cm)	Total water expense (cm)	Native profile water use (cm)	Water expense efficiency (kg/ha-cm)	Leaf area at (80 DAS** (cm^2/15 cm linear row)	Root length density (cm/cm^3) of surface soil	Total water added through irrigation & rainfall*(cm)	Total water expense (cm)	Native profile water use (cm)	Water expense efficiency (kg/ha-cm)	Leaf area at 150 DAS** (cm^2/plant)	Root length density (cm/cm^3) of surface soil (0–15cm)
Control	31.2	38.7	7.0	37.7	407.1	1.2	38.9	46.0	7.0	40.5	954.2	0.7
FYM	31.2	38.5	7.3	42.1	640.2	1.9	39.3	49.4	10.1	44.2	1619.8	1.3
BGA	30.5	36.5	6.0	45.2	573.7	1.5	40.7	48.4	7.6	45.5	1350.5	0.8
FYM + BGA	30.6	38.3	7.7	47.3	682.8	1.7	39.1	49.5	10.4	52.1	1588.8	0.9
50% NPK	30.7	38.7	8.0	67.9	517.9	1.8	39.1	47.2	8.1	65.2	2082.2	0.8
50% NPK + FYM	31.4	39.2	7.8	73.4	795.3	2.6	39.1	48.8	9.7	79.9	1840.0	1.5
50% NPK + BGA	28.7	37.7	9.0	70.8	703.1	2.4	38.8	46.4	7.6	73.7	1745.6	1.2
50% NPK+ FYM + BGA	32.2	38.8	6.6	82.6	853.2	3.1	41.2	49.4	8.2	84.7	3139.0	1.4
100% NPK	30.1	38.8	8.7	79.1	870.2	2.6	38.7	48.4	9.7	85.8	2603.3	1.4
100% NPK + FYM	30.3	38.7	8.4	96.4	1266.6	3.2	40.8	49.7	8.9	94.1	2876.5	1.8
100% NPK + BGA	32.8	40.4	7.6	83.4	1140.3	3.1	38.6	46.7	8.2	91.4	2811.0	1.6
100% NPK + FYM + BGA	31.7	40.5	8.7	98.2	1145.3	3.4	40.4	46.8	7.6	100.3	3545.5	2.2
S.Em+		6.6	2.2	6.8	61.5	0.11		2.5	3.2	7.1	79.1	0.14
CD (0.05)		NS	NS	21.4	189.8	0.32		NS	NS	22.2	234.8	0.56

* 4.08 cm water added through effective rainfall between sowing and harvesting

** DAS – days after sowing

the crops in general is more than 100 per cent. This shows that a sizeable amount of non-exchangeable K contributed towards potassium uptake of the crops. Such possibilities had been reported earlier by Sachadeva and Khera (1980). Thus, it may be concluded that nutrient and water use efficiencies can be enhanced in wheat and winter maize through integrated nutrient management involving fertilizers, BGA and FYM in calcareous silt loam soils of Bihar.

Table 2. Effect of integrated nutrient management on nutrient use efficiency (%)

Treatments	Wheat			Winter maize		
	N	P	K	N	P	K
50% NPK	47.6	19.4	135.3	45.8	16.7	144.1
50% NPK + FYM	60.6	28.2	164.9	60.3	22.0	180.0
50% NPK + BGA	51.1	24.7	152.3	50.1	21.1	174.1
50% NPK + FYM + BGA	56.4	29.3	160.3	58.3	23.6	174.0
100% NPK	37.7	16.0	114.3	41.0	13.4	141.0
100% NPK + FYM	47.7	21.8	156.3	48.8	19.8	158.1
100% NPK + BGA	43.8	18.9	144.2	46.0	18.5	137.5
100% NPK + FYM + BGA	50.1	26.1	156.7	51.0	20.2	164.8

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