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Effect of Spatial Variability and Nutrient Management Practices on Growth and Yield Attributes in Maize-Groundnut Cropping Sequence

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Abstract

Field studies were conducted during *kharif* and *rabi* / summer 2014-15 to know the spatial variability and effect of nutrient management practices on growth and yield attributes in maize - groundnut cropping sequence at Zonal Agricultural Research Station, GKVK, Bengaluru. The experimental fields were delineated in to 36 grids of 9 m x 9 m using geospatial technology. Soil samples from 0-15cm depth were collected and analysed. There was spatial variability for available nitrogen, phosphorous and potassium during *kharif* 2014 (123 to 246kg N, 5.4 to 10.0 kg P_2O_5 and 191 to 458 kg K_2O ha^{-1}) and *rabi* / summer 2014-15 (99 to 197 kg N, 12.1 to 64.0 kg P_2O_5 and 166 to 402 kg K_2O ha^{-1}). This was addressed through SSNM strategy with target yield approach. Application of NPK through drip fertigation in 6 equal splits at fortnightly interval recorded significantly higher growth and yield attributes of maize and groundnut. Application of variable rates of NPK based on NPK variability of grids through drip fertigation in six equal splits at fortnightly interval recorded 11.14 per cent higher maize yield (102.38 q ha^{-1}) and 27.28 per cent higher groundnut pod yield (25.24 q ha^{-1}) over blanket soil application as per the recommended dose of fertilizers (92.12 q ha^{-1} maize and 19.83 q ha^{-1} groundnut).

Maize (*Zea mays* L.) is one of the widely grown cereal crops next to wheat and rice throughout the world due to its multiple uses, as poultry and cattle feed, preparation of corn flakes, pop corn, starch, dextrose, corn syrup and corn oil *etc*. In Karnataka, it is grown over an area of 13.22 lakh ha with a production of 34.75 lakh tones and average productivity of 2629 kg ha^{-1} (Anon., 2014). The area under maize in Karnataka has increased by 41 per cent during the last 10 years. In the agricultural economy of India, Groundnut (*Arachis hypogaea* L.) is commonly called 'poor man's almond'. It ranks fourth and third place as a source of edible oil and vegetable protein, respectively.

In Eastern Dry Zone of Karnataka, Maize-groundnut sequential cropping system is gaining importance because of profitability and sustained demand in the market. Being exhaustive crops, mineral nutrition is the key to optimize the production. Maize removes nearly 20.1 kg N, 9.4 kg P_2O_5 and 24.7 kg K_2O to produce 1 ton of grain. Similarly, groundnut crop yielding 20 to 25 q ha^{-1} of economic yield, requires 160-180 kg N, 20-25 kg P_2O_5, 80-100 kg K_2O which indicates higher demand for nitrogen, phosphorous and potassium.

Traditionally crops are grown under blanket recommendation of fertilizers with conventional method of irrigation, leading to low nutrient use efficiency and lower profits, which also failed to exploit full potential under spatial variability of soil nutrients (Pampolino *et al*., 2012). This management protocol often results in over-application in some field areas and under application in others due to spatial variation in soil available nutrients. So, it is imperative to use fertilizers judiciously to reduce the dependence on non renewable sources and to increase profits. Site specific management of zones within field on cluster basis coupled with target yield approach is known to enhance the nutrient use efficiency. In this background, grid based application of nutrients through drip irrigation with split application as per crop demand was carried out in maize – groundnut sequence.

The field experiment was conducted during *kharif* and *rabi* / summer 2014-15 at Zonal

Agricultural Research Station, UAS, GKVK, Bengaluru. The experimental site is situated at 13^o 05' 22" North latitude and 77^o 34' 04" East longitude with an altitude of 933 m above mean sea level. Thirty six grids of 9.0 m × 9.0 m were formed. Soil samples from each grid were collected during May and November 2014 from the four equidistant spots and at the centre of the grid from 0 - 15 cm soil depth. Based on the variability in soil for available NPK required for targeted yields of 75, 90 and 105q maize ha^{-1} were calculated using STCR equations. Fertilizer N required = 3.84 T - 0.42 Soil available N, Fertilizer P_2O_5 required = 1.57 T - 1.18 Soil available P_2O_5 and Fertilizer K_2O required = 1.15 T - 0.11 Soil available K_2O, where T is targeted yield.

Similarly, the NPK fertilizer required for groundnut for the targeted yields of 15, 20 and 25q ha^{-1} was calculated using the equations; F.N = 6.39 T – 0.48 S.N, F. P_2O_5 = 15.50 T - 10.20 S. P_2O_5 and F. K_2O = 8.68 T - 0.80 S. K_2O. The average quantity of NPK used for targeted yields (T.Y) of maize and groundnut are given Table 1. Recommended NPK for maize 150:75:40 kg N, P_2O_5 and K_2O ha^{-1} and groundnut 25:75:38 kg N, P_2O_5 and K_2O ha^{-1} were the controls.

The fertilizers were applied adopting three methods *viz*., M_1: Application of nutrients as per UAS (B) package of practice (50% N and entire P_2O_5 and K_2O as basal and remaining N at 30 days after sowing as top dress for maize while, entire recommended N, P_2O_5 and K_2O was applied to groundnut at sowing), M_2: Application of fertilizer in 12 equal splits at weekly interval through drip irrigation, M_3: Application of fertilizer in 6 equal splits at fortnightly interval through drip irrigation. The experiment was laid out in split plot design. The methods of application comprised of main plot and fertilizer levels for targeted yield and the recommended NPK for maize / groundnut (control) comprised the sub plot treatments. In all there were 12 treatments.

Maize hybrid NAH-1137 was sown on 9 July, 2014 and groundnut variety ICGV-91114 was sown on 31st Dec. 2014. Spacing adopted for maize and groundnut was 60cm X 30cm and 30cm X 10cm respectively. Fertilizers as per the treatments were applied through urea, MOP and water soluble MAP, 19-19-19 and 17-44. Data on growth and yield attributes of maize and groundnut were recorded and statistically analyzed.

Grid-wise status of soil available nitrogen, phosphorus and potassium during May 2014 and November 2014 are depicted in Fig. 1and 2. The data revealed spatial variability of soil available nitrogen, phosphorous and potassium during both the seasons. The variability was from 123 to 246, 99 to 197 kg for N, 5.4 to 10.0, 12.1 to 64.0 kg for P_2O_5 and 191 to 458, 166 to 402 kg for K_2O ha^{-1}, respectively during *kharif* and *rabi* / summer 2014-15. This permits site-specific nutrient management either through yield based

TABLE I

Average quantity of nitrogen, P_2O_5 and K_2O (kg ha^{-1}) applied for targeted yield levels (q ha^{-1}) of maize and groundnut

Maize				Groundnut			
Targeted yield	Nitrogen	P_2O_5	K_2O	Targeted yield	Nitrogen	P_2O_5	K_2O
	kg ha^{-1}				kg ha^{-1}		
75	236	109	61	15	31	10	17
90	275	131	75	20	64	24	26
105	317	156	89	25	85	57	51

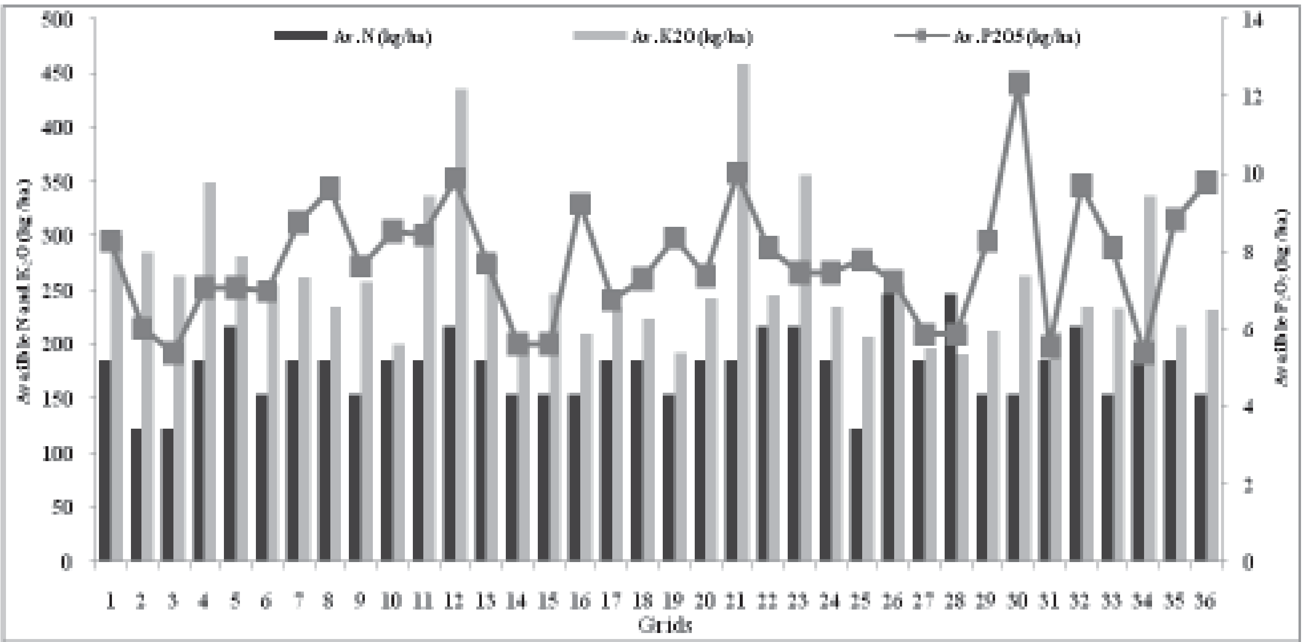

Fig. 1. Spatial variability of soil available nitrogen, phosphorus and potassium in the experimental site during May 2014

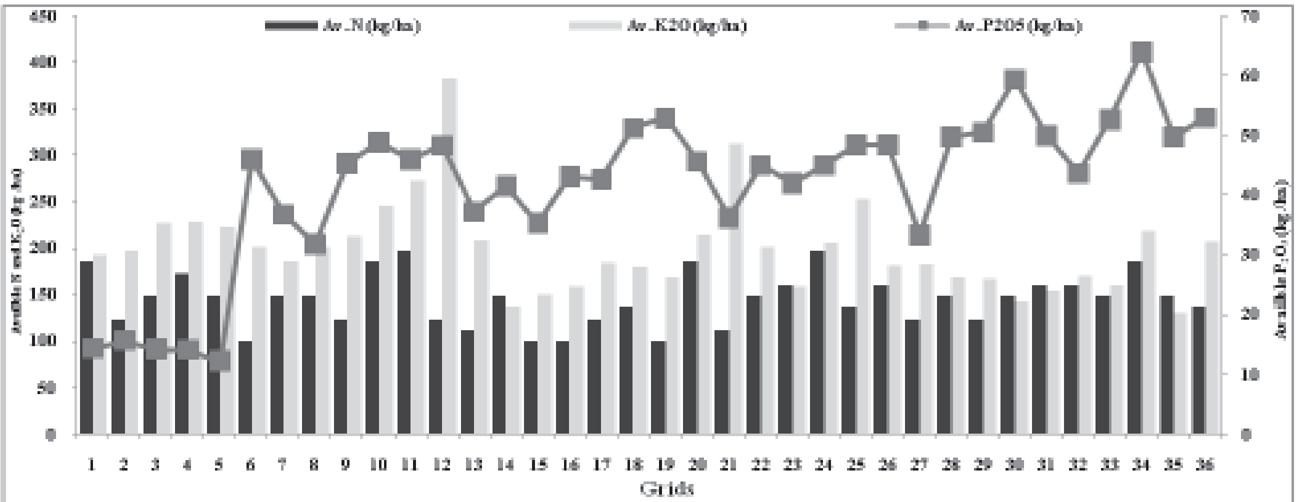

Fig. 2. Spatial variability of soil available nitrogen, phosphorus and potassium in the experimental site during Nov.2014

management concepts or through grid based concept (Tawainga *et al.*, 2003).

Plant height, number of leaves plant^{-1}, leaf area plant^{-1}, and SPAD Chlorophyll values of maize differed significantly (Table 2). Application of NPK through drip irrigation in 6 equal splits at fortnightly interval recorded significantly more number of leaves (13.9) and leaf area (8757 cm^2) plant^{-1} as compared to general recommended dose. The targeted yield of 105q ha^{-1} recorded significantly more number of leaves (14.3) and leaf area (9541 cm^2) plant^{-1}. Application of fertilizers for targeted yield of 105q ha^{-1} recorded significantly taller plants (215.6 cm) at harvest. The increased plant height was due to increased efficiency in nutrient availability which contributed for prolonged greenness and larger leaf surface. Similar observations on improved growth parameters due to application of higher levels of NPK were revealed by Singh *et al.* (2003).

Application of nutrients synchronizing with crop demand enhanced growth and improved the efficiencies of fertilizers. Chlorophyll content of the leaf indicates the N status of the leaves. At 90 DAS, application of fertilizers through drip irrigation in 6 equal splits at fortnightly interval recorded significantly higher SPAD chlorophyll value (44.1) over normal method of application (37.7). Among the targets, application of fertilizers for targeted yield of 105q ha^{-1} recorded higher SPAD chlorophyll readings (46.5). The results are in accordance with the findings of Suryavanshi *et al.* (2008).

Data pertaining to yield attributes (Table II) revealed that, application of fertilizers through drip irrigation in 12 equal splits at fortnightly interval recorded significantly higher cob length (18.77 cm), number of kernels per cob (650) and 100 kernel weight (36.9 g). Among the targets, targeted yield of 105q ha^{-1} recorded significantly higher cob length (19.54 cm), number of rows cob^{-1} (16.5), number of kernels cob^{-1} (696) and 100 kernel weight (38.7 g) which was followed by targeted yield of 90 q ha^{-1} as compared to other treatments. Significantly lower values were recorded for recommended dose of fertilizer. The results are in conformity with the findings of Singh *et al.* (2003). The enhanced values of yield attributes could be ascribed to the tendency of nitrogen in accelerating growth, photosynthetic activity and translocation efficiency for photosynthates in presence of increasing NPK rates.

Grain yield of maize differed significantly due to nutrient management practices and different targeted yield levels (Table 2). Significantly higher maize grain yield (111.54q ha^{-1}) was recorded with the application of fertilizers through the drip irrigation in 6 equal splits

TABLE II

Growth, yield and yield attributers of maize as influenced by nutrient management practices and targeted yield levels

Treatments	Plant height (cm)	Leaves $plant^{-1}$	Leaf area (cm^2)	SPAD values at 90 DAS	Cob length (cm)	Rows cob^{-1}	Kernels cob^{-1}	100 kernelweight (g)	Grain yield(q ha^{-1})	Stover yield(q ha^{-1})
Main plots (Application method)										
M_1	206.1	13.5	7879	37.7	17.58	16.1	590	34.0	92.12	96.38
M_2	204.5	13.9	8229	43.0	18.14	16.2	615	35.2	96.19	102.08
M_3	201.3	13.9	8757	44.1	18.77	16.2	650	36.9	102.38	106.12
S.E.m+	0.3	0.0	119	0.1	0.29	0.1	7.0	0.1	1.39	0.86
CD at 5%	1.0	0.1	465	0.5	1.12	NS	29.0	0.5	5.44	3.38
Sub-plots (Targeted yield levels)										
Y_1	199.1	13.7	7657	41.5	17.68	16.0	606	34.0	89.50	95.23
Y_2	207.8	13.9	8668	43.1	18.81	16.2	641	36.5	101.33	104.72
Y_3	215.6	14.3	9541	46.5	19.54	16.5	696	38.7	111.54	115.38
Y_4	193.3	13.1	7286	35.4	16.62	15.9	530	32.3	85.21	90.78
S.E.m+	0.2	0.0	127	0.3	0.26	0.1	8.0	0.2	1.46	0.68
CD at 5%	0.5	0.1	377	0.9	0.77	0.3	24.0	0.5	4.35	2.01
Interactions (M x Y)										
S.E.m+	0.3	0.03	220	0.5	0.45	0.2	14.0	0.3	0.94	0.51
CD at 5%	0.8	NS	NS	NS	NS	NS	NS	0.8	NS	NS

Note: Y_1: 75 q ha^{-1} Y_2: 90 q ha^{-1} Y_3: 105 q ha^{-1} Y_4: RDF at fortnightly interval over soil application as per UAS, B package of practice (92.12q ha^{-1}). Application of fertilizers for targeted yield of 105q ha^{-1} recorded significantly higher actual maize grain yield (111.54q ha^{-1}) over rest of the targets. The actual yields (89.50, 101.33 and 111.54q ha^{-1}) were 3.9 to 17.1 per cent higher than the targeted yields (75, 90 and 105q ha^{-1}, respectively) and significantly lower grain yield of 85.21q ha^{-1} was recorded with recommended dose of fertilizers. Stover yield of maize also followed the similar trend (Table 3). The results are in conformity with the findings of Trinh *et al.* (2008).

Growth, yield attributes, pod yield and haulm yield of groundnut (Table 3) varied significantly with nutrient management practices. Application of NPK through drip irrigation in 12 equal splits at weekly interval recorded significantly taller plants (40.1 cm) and more number of branches (7.8) over blanket soil application but it was on par with the application of NPK through drip irrigation in 6 equal splits at fortnightly interval (38.2 cm and 7.6 respectively). Significantly higher pod dry weight (68.52 g plant^{-1}) was observed with the application of fertilizers through drip irrigation in 6 equal splits at fortnightly interval over soil application as per UASB package of practices (55.28 g plant^{-1}). Among the targets, targeted yield of 25q ha^{-1} recorded significantly more pod dry weight (75.18 g plant^{-1}). Similar trend was observed with respect to SPAD values recorded at 90 days after sowing.

The data pertaining to number of pods per plant and 100 kernel weight as influenced by nutrient management practices and different targeted yield levels of groundnut are presented in Table 3. Data showed that, application of fertilizers through drip irrigation in 12 equal splits at fortnightly interval recorded significantly higher number of pods plant^{-1}

TABLE III

Growth, yield and yield attributes of groundnut as influenced by nutrient management practices and targeted yield levels

Treatments	Plant height (cm)	Primary branches plant $^{-1}$	SPAD values	Pods plant $^{-1}$	Podsdry weight(g plant $^{-1}$)	100-kernel weight (g)	Pod yield (q ha^{-1})	Haulm yield (q ha^{-1})	Shelling (%)
				Main plots (Application method)					
M_1	36.3	7.0	42.73	27.3	55.28	27.23	19.83	25.67	66.3
M_2	40.1	7.8	44.94	44.2	67.27	29.11	24.02	30.00	65.7
M_3	38.2	7.6	45.92	43.6	68.52	30.62	25.24	31.08	67.7
S.E.m+	1.1	0.2	0.44	1.1	0.30	0.23	0.24	1.21	0.26
CD at 5%	4.3	0.8	1.71	4.4	1.2	0.94	1.13	4.75	1.03
				Sub-plots (Targeted yield levels)					
Y_1	36.1	7.1	43.05	31.7	57.23	28.43	20.55	27.29	65.8
Y_2	38.4	7.6	44.65	37.0	67.31	29.30	23.97	29.14	66.5
Y_3	41.7	8.1	45.66	49.4	75.18	29.93	27.35	31.69	67.4
Y_4	36.4	7.0	44.77	35.2	55.02	28.28	20.25	27.54	66.5
S.E.m+	0.5	0.1	0.59	1.1	0.52	0.51	0.24	1.27	0.28
CD at 5%	1.4	0.4	1.75	3.3	1.56	NS	0.70	3.77	0.82
				Interactions (M x Y)					
S.E.m+	0.8	0.2	0.49	1.9	0.9	0.88	0.36	2.20	0.48
CD at 5%	NS	NS	NS	NS	2.7	NS	NS	NS	NS

Note: Y_1: 15 q ha^{-1} Y_2: 20 q ha^{-1} Y_3: 25 q ha^{-1} Y_4: RDF

(44.2) over blanket application as per UAS (B) package of practices (27.3) and was on par with the application of nutrients through drip irrigation in 6 equal splits at fortnightly interval (43.6). Among the targets, fertilizers applied for targeted yield of 25q ha^{-1} recorded significantly more number of pods $plant^{-1}$ (49.4) and it was followed by targeted yield of 20q ha^{-1} as compared to other treatments. Significantly higher 100-kernel weight (30.62 g) was registered with the application nutrients through drip irrigation in 6 equal splits at fortnightly interval over normal blanket application as per UAS (B) package of practice (27.23 g) but was on par with the application through drip irrigation in 12 equal splits at weekly interval (29.11g).

Pod yield of groundnut differed significantly due to nutrient management practices (Table 3). Application of nutrients through the drip irrigation in 6 equal splits at fortnightly interval recorded significantly higher pod yield (25.24 q ha^{-1}) over soil application as per UAS, B package of practice (19.83 q ha^{-1}) and fertilizer application through drip irrigation in 12 equal splits at weekly interval (24.02 qha^{-1}). Drip fertigation of NPK in 6 equal splits at fortnightly interval also produced significantly higher haulm yield (31.08 q ha^{-1}) as compared to all other treatments (Table 4). However it was on par with the application of fertilizer through drip irrigation in 12 equal splits at weekly interval (30 q ha^{-1}). Among the targets, significantly higher pod yield of 27.35 q ha^{-1} was recorded as against the target 25q ha^{-1}. The actual yields exceeded the targeted yield levels (15, 20 and 25q ha^{-1}) by 37.0, 19.9 and 9.3 per cent respectively. The positive response to higher level of nutrients on pod yield was ascribed to overall improvement in crop growth which enabled the plant to absorb more nutrients and moisture as a consequence the plants are able to synthesize more of photosynthates. Thus there is balance in source and sink which resulted in higher economic yield of groundnut. The nutrient supplied through drip irrigation at 6 and 12 equal splits matched with crop demand, which led to efficient utilization of applied fertilizer. Similar results were also reported by Jain *et al.* (2012).

It could be concluded that, variable rate application of NPK through drip irrigation in 6 equal splits at fortnightly interval enhanced growth, yield attributes and finally the maize kernel and groundnut pod yield by 11.14 and 27.28 per cent respectively over blanket application. Further, the quantity of nitrogen, phosphorous and potassium applied for targeted yield levels of maize and groundnut in maize - groundnut cropping sequence clearly reveals saving in phosphatic fertilizer required for groundnut crop due to application of NPK through SSNM strategy to maize over blanket application of recommended dose of fertilizer.

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