CONTEMPORARY RESEARCH IN INDIA
ISSN 2231 - 2137

SEQUENCE PRODUCTIVITY AND NUTRIENT BALANCE IN MAIZE BASED VEGETABLE CROPPING SEQUENCES

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Received: 04/04/2018 | **Edited: 12/04/2018** | **Accepted: 21/04/2018**

Abstract: *A field experiment was conducted at Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra) with the objectives to study the system productivity and nutrients performance in maize based vegetable cropping sequences (maize-onion, maize-garlic and maize-potato) under different nutrient management treatments during 2014-15 and 2015-16. The application of fertilizer dose as per soil test crop response (STCR) with FYM recorded highest yield of kharif maize (94.78 q ha^{-1}) than rest of the treatments. The target of 100 q ha^{-1} was achieved by STCR equation with less than 10 per cent variation (± 5.22). Under rabi crops, the application of fertilizer dose as per STCR equation with FYM to kharif maize recorded maximum and significantly higher yields of onion bulb, garlic bulb and potato tuber than rest of the nutrient management treatments during both the years and pooled mean. The application of 125 per cent general recommended dose of fertilizer to rabi onion, garlic and potato registered significantly higher yields of onion bulb, garlic bulb and potato tuber than 100 and 75 per cent general recommended dose of fertilizer during both years and on pooled mean.*

At the end of two years crop sequence, all the maize based cropping sequences recorded with gain in soil available nitrogen, phosphorus and potassium. However, the maize-garlic cropping sequence recorded maximum gain of nitrogen, phosphorus and potassium with application of fertilizer as per STCR equation without FYM to kharif maize followed by 125 per cent general recommended dose of fertilize to rabi crops.

Key words: *Cropping sequences, nutrient management, productivity and nutrient balance.*

India is self sufficient in food grain production, which has substantially increased from 50.82 million tonnes in 1950-51 to 253.16 million tonnes in 2015-16. By 2020, India has to increase productivity above 340 million tonnes food grains in view of population growth, so agricultural scientists and technologists have to take the efforts to double the productivity of available resources like water, land etc. with less and less resources being available for cultivation of crops and diminishing number of available farmers. Sequence cropping is gaining importance in Indian agriculture. Rotation and sequence cropping plays an important role in cropping system research. Now a day's soil are degrading fast in available nitrogen due to introduction of hybrids and high yielding varieties of various crops (Balyan and Seth, 1985). Different cropping sequences with various suitable grains, legume, fodder, oilseed, vegetable and other high value and remunerating crops in proper sequence give higher crop productivity and also economic returns. In cropping sequence high requirements of nutrients and may adversely affect crop yield in large and hence adequate nutrient management of nutrients is highly essential for sustainable production. It is the need of the hour to conduct the experiments as per the soil test as well as yield targeting equation studies in different cropping sequences in maize based vegetable sequences by using different fertilizer levels. With this view the present study has been undertaken on different maize based vegetables cropping sequences in respect to integrated nutrient management and also to study the response of different nutrients on medium deep soils in Scarcity Zone of Maharashtra.

To increase the production and profitability of maize based cropping sequences and efficiency

and performance of the nutrients an effort was made to carry out an experiment for two consecutive years.

Materials and Methods

A field experiment was carried out during 2014-15 and 2015-16 at Mahatma Phule Krishi Vidyapeeth, Rahuri (M.S.) on sandy clay loam soil with low in available nitrogen (156.80 kg ha^{-1}), medium in phosphorus (17.09 kg ha^{-1}) and high in available potassium (492.80 kg ha^{-1}) and the soil was moderately alkaline in reaction (pH 8.02).

The treatment consists of three cropping sequences viz., C_1- maize-onion, C_2- maize-garlic and C_3- maize-potato with four nutrient management treatments viz., T_1-100% general recommended dose of fertilizer, T_2- 100% recommended dose of fertilizer as per soil test, T_3- Fertilizer dose as per Soil Test Crop Response yield equation for 100 q ha^{-1} targeted yield without FYM, T_4- Fertilizer dose as per Soil Test Crop Response yield equation for 100 q ha^{-1} targeted yield with FYM as main plot treatment whereas three fertilizer levels viz., F_1- 75% general recommended dose of fertilizer, F_2- 100% general recommended dose of fertilizer and F_3 – 125% general recommended dose of fertilizer as sub plot treatments. The experiment was laid out in randomized block design in *kharif* season in nine replications and split plot design in *rabi* season with three replications. Maize- NK-6240, onion- N 2-4-1, galic- Phule baswant and potato- *Kufri jyoti* cultivars were used during *kharif* and *rabi* seasons, respectively. Both the year's crop seasons were favourable to grow the *kharif* and *rabi* crops. The recommended package of practices adopted to grow the crops and fertilizers were applied as per treatments.

Results and Discussion

Productivity of *kharif* crops: Application of fertilizer dose as per STCR equation with FYM recorded maximum and significantly higher grain yield (92.44, 97.12 and 94.78 q ha^{-1}) than rest of the treatments during first, second year and pooled mean. The target of 100 q ha^{-1} was achieved by STCR equation with less than 10 per cent variation (± 5.22). The fertilizer dose as per STCR equation without FYM was found second best treatment (84.11, 88.42 and 86.26 q ha^{-1}) during both years and on pooled mean (Table 1). This might be because of the balanced nutrition through STCR equation with FYM and benefits occurring from the integrated use of FYM might be attributed to better supply of nutrients gives highest grain yield due to better translocation of photosynthates from source to sink These results are in accordance with those obtained by Suresh Naik et al. (2012), Ravikumar (2009) and Veeresh (2010).

Productivity of *rabi* crops

Onion: Data presented in Table 1. indicated that, application of fertilizer dose as per STCR equation with FYM to *kharif* maize registered maximum and significantly higher yield of onion bulb (46.10, 47.06 and 46.58 t ha^{-1}) than rest of the nutrient management treatments during both the years and pooled mean. However, it was at par with the treatment application of fertilizer dose as per STCR equation without FYM to *kharif* maize during second year and also on pooled mean.

Application of 125 per cent general recommended dose of fertilizer to *rabi* onion registered significantly higher yield of onion bulb (44.70, 45.97 and 45.33 t ha^{-1}) than 100 and 75 per cent general recommended dose of fertilizer during both years and on pooled mean. However, it was at par with 100 per cent general recommended dose of fertilizer to *rabi* onion during both years and also on pooled mean. This might be because of the residual effect of preceding crop maintaining soil organic matter, major and micronutrients and graded levels of fertilizers to onion during *rabi* season had a great impact which increases the uptake of these nutrients and accelerating the physiological activities in crop for improving growth attributes. Similarly it also increased the translocation of photosynthates towards the size of (polar and equatorial diameter) and weight of bulb. These results are in conformity with those reported by Konde (2002), Reddy and Suresh (2009) and Jat et al., (2011).

Garlic: Application of fertilizer dose as per STCR equation with FYM to *kharif* maize registered significantly higher yield of garlic bulb (13.22, 14.21

and 13.72 t ha^{-1}) than rest of the nutrient management treatments during both the years and pooled mean. The treatment, fertilizer dose as per soil test registered significantly minimum yield of garlic bulb (10.85, 11.28 and 11.07 t ha^{-1}) during both years and on pooled mean.

Application of 125 per cent general recommended dose of fertilizer to garlic registered significantly higher yield of garlic bulb (12.53, 13.27 and 12.90 t ha^{-1}) than 100 and 75 per cent general recommended dose of fertilizer during both years and on pooled mean. However, it was at par with 100 per cent general recommended dose of fertilizer to garlic during both years and also on pooled mean. This indicates that growing of garlic crop after maize gave higher yield only after increasing fertilizer levels & might be because of the residual effect of preceding crop maintaining soil organic matter, major and micronutrients had a great impact which increases the uptake of these nutrients and accelerating the physiological activities in crop for improving growth attributes and also increased the translocation of photosynthates towards the size and weight of bulb. These results are in conformity with those reported by Jat et al., (2011).

Potato: Application of fertilizer dose as per STCR equation with FYM to *kharif* maize registered maximum and significantly higher tuber yield of potato i.e., 31.66, 32.96 and 32.31 t ha^{-1} during first, second year and on pooled mean during both the years of the experiment than rest of the treatments. However, it was at par with the treatment general recommended dose of fertilizer to *kharif* maize during first year and on pooled mean also.

Application of 125 per cent general recommended dose of fertilizer to potato registered significantly higher tuber yield of potato 31.13, 32.37 and 31.75 t ha^{-1} during first, second year and on pooled mean, respectively, during both years. However, it was at par with 100 per cent general recommended dose of fertilizer to potato during both years and also on pooled mean. This might be because of leaf area index increased with increase in fertilizer doses leading to increased light interception which ultimately resulted in increased total tuber yield (Verma et al., 1997 and Kumar et al., 2002). Sandhu et al., (2013) reported increasing trend was noticed in respect of total tuber yield with increasing fertilizer doses applied. Increasing NPK levels from 180:34.9:100 to 270:52.4:150 kg/ha increased yield of large -sized tubers significantly. This might be due to more bulking of processing grade tubers to large sized tubers, hence yield of large and total tubers improved significantly (Singh et al., 2013).

Performance of Nutrient (kg ha^{-1})

The performance of different nutrients was assessed on the basis of initial nutrient status, nutrient added, uptake of nutrients by crops and available nutrients after harvest of each crops and cropping systems during both the years and presented in Table 2.

Cropping sequences: At the end of two years of crop sequence, it could be seen, all the cropping systems showed gain under nitrogen, phosphorus as well as potassium. The maize-garlic cropping sequence observed maximum gain of nitrogen (174.82 kg ha^{-1}), phosphorus (133.04 kg ha^{-1}) and potassium (120.56 kg ha^{-1}) than rest of all cropping systems. While, maize-potato cropping sequence showed minimum gain in respect to nitrogen, phosphorus and potassium.

Nutrient management: All the nutrient management treatments showed gain of nitrogen, phosphorus and also in potassium. Application of fertilizer as per STCR equation without FYM recorded maximum gain of nitrogen (273.38 kg ha^{-1}) and potassium (129.59 kg ha^{-1}) than rest of all the treatments. Whereas, application of fertilizer dose as per STCR equation with FYM registered maximum gain of phosphorus (147.17 kg ha^{-1}) than rest of the treatments.

Fertilizer levels: All the fertilizer levels indicated gain in nutrients. Among the fertilizer levels, 125 per cent general recommended dose of fertilizer registered maximum gain of nitrogen (209.28 kg ha^{-1}), phosphorus (150.13 kg ha^{-1}) and potassium (135.28 kg ha^{-1}) than rest of the treatments.

On the basis of two years of experiment, it could be concluded that, at the end of two years crop sequence, all the maize based cropping sequences recorded with gain in soil available nitrogen, phosphorus and potassium. However, the maize-garlic cropping sequence recorded maximum gain of nitrogen, phosphorus and potassium with application of fertilizer as per STCR equation without FYM to *kharif* maize followed by 125 per cent general recommended dose of fertilize to *rabi* crops.

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Table 1: Yield of component crops in different cropping sequences as influenced by different treatments

Treatment	Maize grain yield (q ha^{-1})			Onion bulb yield (t ha^{-1})			Garlic bulb yield (t ha^{-1})			Potato tuber yield (t ha^{-1})		
	2014-15	2015-16	Pooled mean	2014-15	2015-16	Pooled mean	2014-15	2015-16	Pooled mean	2014-15	2015-16	Pooled mean
T_1	75.23	80.01	77.62	44.83	45.63	45.23	12.09	12.94	12.52	31.01	32.28	31.64
T_2	68.11	71.52	69.81	40.67	42.46	41.57	10.85	11.28	11.07	28.95	30.16	29.56
T_3	84.11	88.42	86.26	42.44	43.80	43.12	11.11	11.93	11.52	29.65	30.86	30.26
T_4	92.44	97.12	94.78	46.10	47.06	46.58	13.22	14.21	13.72	31.66	32.96	32.31
S.Em. ±	2.01	1.75	1.88	0.27	0.45	0.45	0.24	0.16	0.26	0.23	0.12	0.22
C.D. at 5%	5.97	5.20	5.60	0.93	1.56	1.40	0.86	0.58	0.80	0.80	0.42	0.70
Fertilizer levels												
F_1	-	-	-	41.83	42.96	42.39	10.72	11.52	11.12	29.19	30.39	29.79
F_2	-	-	-	44.01	45.29	44.65	12.20	12.99	12.59	30.63	31.95	31.29
F_3	-	-	-	44.70	45.97	45.33	12.53	13.27	12.90	31.13	32.37	31.75
S.Em. ±	-	-	-	0.30	0.26	0.33	0.20	0.15	0.22	0.20	0.16	0.22
C.D. at 5%	-	-	-	0.88	0.77	0.97	0.62	0.46	0.64	0.60	0.50	0.65
General mean	79.97	84.27	82.12	43.51	44.74	44.12	11.82	12.59	12.21	30.32	31.57	30.95

T_1 - General recommended dose of fertilizer, T_2 - 100 % recommended dose of fertilizer as per soil test,
T_3 - Fertilizer dose as per STCR eq^n (100 q ha-1), T_4 - Fertilizer dose as per STCR eq^n (100 q ha-1) + FYM,
F_1 - 75% General recommended dose of fertilize, F_2 - 100% General recommended dose of fertilize,
F_3 - 125% General recommended dose of fertilizer

Table 2: Balance sheet of mean available soil nitrogen, phosphorus and potassium as influenced by different system (2014-16)

Treatment		A: Initial soil status (kg ha^{-1})			B: Nutrients added (kg ha^{-1})			C: Nutrients uptake (kg ha^{-1})			D: Soil nutrients after harvest of crops (kg ha^{-1})			(A+B)-(C+D) : Soil nutrient balance (kg ha^{-1})		
		N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
Cropping system																
C_1	Maize-onion	156.80	17.09	492.80	919.58	329.11	626.32	778.30	223.48	537.16	185.22	27.24	512.70	112.86	95.48	69.26
C_2	Maize-garlic	156.80	17.09	492.80	918.34	329.86	632.24	710.10	184.50	487.17	190.22	29.41	517.32	174.82	133.04	120.56
C_3	Maize-potato	156.80	17.09	492.80	1021.21	336.94	741.19	942.56	240.15	657.39	178.99	26.60	505.58	56.46	87.29	71.02
Nutrient management																
T_1	GRDF	156.80	17.09	492.80	777.10	316.40	608.75	657.00	194.86	485.03	188.85	28.61	523.00	88.05	110.02	93.53
T_2	AST	156.80	17.09	492.80	732.00	254.38	465.26	588.65	171.16	439.75	179.36	26.41	489.02	120.79	73.90	29.29
T_3	STCR	156.80	17.09	492.80	1114.90	348.65	681.75	812.99	211.87	531.35	185.32	27.92	513.60	273.38	147.17	129.59
T_4	STCR+FYM	156.80	17.09	492.80	1051.84	398.51	761.35	918.15	238.07	592.53	197.35	30.36	534.41	93.14	125.95	127.21
Fertilizer levels																
F_1	75% GRDF	156.80	17.09	492.80	810.96	279.48	546.26	706.69	193.10	486.82	173.14	23.17	487.49	87.92	80.31	64.75
F_2	100% GRDF	156.80	17.09	492.80	918.96	329.28	620.37	753.88	205.94	515.54	187.57	28.10	512.95	134.31	112.34	84.68
F_3	125% GRDF	156.80	17.09	492.80	1026.96	379.68	721.21	772.03	212.93	534.13	202.45	33.72	544.59	209.28	150.13	135.28
	General mean	**156.80**	**17.09**	**492.80**	**918.96**	**329.48**	**629.28**	**744.20**	**203.99**	**512.16**	**187.72**	**28.33**	**515.01**	**143.84**	**114.26**	**94.91**