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Effect of Graded Levels and Split Application of Nitrogenon Plant Nutrient Uptake, Post-Harvest Soil Available Nutrients and Economics of Hybrid Maize (Co MH-6)

S. V. Varshini*, R. Babu

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ABSTRACT

A field experiment to study the effect of graded levels and split application of nitrogen on plant nutrient uptake, post-harvest soil available nutrients and economics of hybrid maize CO MH-6 was conducted at AC and RI, Madurai. A RBD design with three replications was adapted for the study with treatments comprises of RDN (250 kg/ha) and STCR (167 kg/ha) on three splits and nitrogen levels 225, 200, 175 and 150 kg/ha under three splits and four splits. The results observed shows that higher plant nutrient uptake of NPK was with T_1 at 30, 45DAS and with T_7 at 60 and harvest. For post-harvest soil available nutrients (NPK) T_6 Showed better results. Similarly for economics the cost of cultivation was high with T_1, whereas gross return, net return and BC ratio was higher with T_7.

Keywords: Nitrogen - optimization, Split - application, STCR, CO (MH) 6, Productivity.

S. V. Varshini*
PhD. Scholar, Agricultural College and Research Institute,
Tamil Nadu Agricultural University, Coimbatore 641003, India
Email: varshuagri08@gmail.com

R. Babu
Professor of Agronomy, Agricultural College and Research Institute, Kudumiyanmalai 622104,
Tamil Nadu Agricultural University, India
Email: rbabu67@gmail.com

INTRODUCTION

Maize (*Zea mays* L.) a family of Poaceae is cultivated globally and it is the third most important cereal. Maize is known to be one of the widely recognized food and fodder crop around the world. The wide recognition that the maize had can explained by the name it has as “miracle crop” and “queen of cereals”all around the globe. At present maize is cultivated at 177.73 million hectares globally and it has a production of about 961.85 million tonnes and a productivity of 5.41 metric tonnes per hectare (USDA 2017). In India 8.81 million hectares of land is used for maize cultivation with a production of 22.57 million tonnes and a average yield of 2.56 metric tonnes per hectare (USDA 2017). Studies stated that at 2020 the requirement of maize for various sectors will be around 100 million tonnes, of which the demand in poultry sector alone will be around 31 million tones. It is a very difficult task for our agriculturists to increase the maize production from the present level of 34 million tonnes to 100 million tonnes by 2020.

Nitrogen, phosphorus and potassium are the essential nutrients for the production of maize. They play a crucial role in deciding the growth and yield. On the other hand, intensive cultivation results in considerable removal of already deficient nitrogen from the soil and their replenishment through organic manure is very limited since the extent at which we produce, do not match to efficiency of the chemical N-fertilizers. Thus newly evolved hybrids with good yield potential show positive response to high levels of N fertilizers and their application becomes necessary even though they are costly. It is inevitable that N-fertilizer usage cannot be avoided but must be optimize the usage in order to obtain a sustainable growth in both in production and farming.

Time and method of N application plays an important role in efficient utilization.The time of application of nitrogen is critical and is regarded as the most important decision for high yielding hybrid maize production (Walsh 2006). The rapid developmental phase of maize starts from V_6 during the highest N uptake takes place. Therefore, maize responds to the belated N application. Generally the N application from V_8 to V_{10} growth stages could be the appropriate time of N supply to meets its high demand (Hassan *et al*. 2010). Nitrogen application during late vegetative growth was considered to be ideal a application practice as a means to increase nitrogen use efficiency Muthukumar *et al.* (2005).

At present the recommendation of nitrogen is 250 kg/ha with three splits at basal (25%), 25 DAS (50%) and 45 DAS (25%). Hence, it was observed that there is scope for extended split application of nitrogen with graded level of nitrogen application.

Generally, N uptake improved and grain yield increased with split N fertilization compared to one single application at planting under irrigation system. Also the split application at different plant growth stages leads to increase in yield attributes of maize (Sangoi *et al.* 2007). Thus the present attempt was made to study the influence of graded levels of N fertilizer and timing of split application of N fertilizer in increasing plant nutrient uptake, post-harvest soil available nutrient and also achieving better economics.

MATERIALS AND METHODS

The experiment was conducted at the Department of Farm Management at AC and RI, Madurai (Tamil Nadu) during the *rabi* season of 2016-2017 at location of 9°54' N latitude, 78°54' 'E' longitude and 147 m altitude above mean sea level with an average rainfall of 856 mm. The soil is sandy clay loam with low organic carbon (4.4 g/kg), low available nitrogen (242.3 kg/ha), medium in phosphorus (16 kg/ha) and high in potassium (450 kg/ha). The soil pH is 8.1 and with an EC is 0.17 dSm^{-1}.

The Randomized Block Design with three replications was adapted for the study with treatments as applying six levels of nitrogen with three and four respective splits at different growth stages as T_1: RDN (250 kg/ha) in3 splits at basal (25%), 25 DAS (50%) and 45 DAS (25%), T_2: STCR (167 kg N/ha) in 3 splits at basal (25%), 25 DAS (50%) and 45 DAS (25%), T_3: 225 kg N/ha in 3 splits at 7 DAS (25%), 25 DAS (50%) and 45 DAS (25%), T_4: 200 kg N/ha in 3 splits at 7 DAS (25%), 25 DAS (50%) and DAS (25%), T_5: 175 kg N/ha in 3 splits at 7 DAS (25%), 25 DAS (50%) and 45 DAS (25%), T_6: 150 kg N/ha in 3 splits at 7 DAS (25%), 25 DAS (50%) and 45 DAS (25%), T_7: 225 kg N/ha in 4 equal splits at 7 DAS, 25 DAS, 45 DAS, 60 DAS, T_8: 200 kg N/ha in 4 equal splits at 7 DAS, 25 DAS, 45 DAS, 60 DAS, T_9: 175 kg N/ha in 4 equal splits at 7 DAS, 25 DAS, 45 DAS, 60 DAS T_{10}: 150 kg N/ha in 4 equal splits at 7 DAS, 25 DAS, 45 DAS, 60 DAS. P and K was applied with the recommended dose of 75 kg/ha (RDF) as basal along with doses of phosphorus and potassium. The variety maize hybrid Co MH 6 was used and their seeds were sown on the side of the ridges by adopting a spacing of 60 × 25 cm. STCR recommendations for T_2 was obtained based on the fertilizer prescription equations (FPE) described for Palaviduthi series obtained from the STCR unit of the Department of Soil Science and Analytical Chemistry, Tamil Nadu Agricultural University, Coimbatore.

$$FN = 3.96\ T - 0.62\ SN - 0.69\ ON,$$

$$FP_2O_5 = 1.56\ T - 1.93\ SP_2O_5 - 0.60\ OP,$$
$$FK_2O = 1.66\ T - 0.27\ SK_2O - 0.49\ OK.$$

Irrigation for the field is on need basis at an interval of 8 to 10 days. Pre-emergence herbicide atrazine was applied on 3 DAS @ 0.5 kg a.i./ha by using knapsack sprayer and followed by subsequent hand weeding when needed. Plant samples were collected at 30, 45, 60 DAS and harvest for analysing the nutrient uptake by corn. The plant samples of corn were oven dried (75oC), chopped and ground into powder in Willey mill. The powdered samples were stored in butter covers for further analysis of total N, P and K.

Nitrogen content in the plant sample was estimated by micro-kjeldhal method as per the procedure given by Humphries (1956). Similarly phosphorus content in the plant sample was estimated by Vanadomolybdo phosphoric yellow color method as suggested by Jackson (1973) by using spectrophotometer at 470 nm (photoelectric colorimeter with blue filter). The phosphorus content was determined by referring to a standard curve and the uptake was expressed as percentage on dry weight basis and computed to kg/ha. Potassium content in plant was estimated from the samples by triple extract using flame photometer as suggested by Jackson (1973). It was expressed as percentage on dry weight basis and computed to kg/ha. However at harvest grain samples and stover samples analyzed separately and the nutrient uptake was calculated by adding the nutrient uptake by both grain and stover and expressed in kg/ha.

Post-harvest samples were collected separately from each plot, the available NPK was estimated as per the procedures suggested by Subbiah and Asija (1956), Olsen *et al.* (1954), Stanford and English (1949) respectively. The expenditure incurred from sowing to harvest was calculated and expressed in Rs/ha. Total income obtained from grain and stover yield were calculated for individual treatments. Cost of cultivation, gross return, net return and benefit cost ratio were calculated using the price of inputs and produce that prevailed during the crop season. Cost benefit analysis was computed for all the treatments using the following formula :

(i) Gross return (Rs/ha) = Economic yield (kg/ha) × Market value of the produce (Rs/kg)

(ii) Net return (Rs/ha) = Gross return (Rs/ha) – Cost of cultivation (Rs/ha)

$$\text{(iii) Benefit: Cost ratio} = \frac{\text{Gross return (Rs/ha)}}{\text{Cost of cultivation (Rs/ha)}}$$

RESULTS

Plant nutrient uptake

Nitrogen uptake

The results from the study (Table1) shows us that, at 30 DAS, uptake of nitrogen was highest (18.77 kg/ha) with application of 250 kg/ha of nitrogen in three splits at basal (25%), 25 DAS (50%) and 45 DAS (25%) (T_1). The lowest uptake of nitrogen (12.72 kg/ha) was associated with application of 150 kg/ha of nitrogen in four equal splits 7 DAS, 25 DAS, 45 DAS and 60 DAS (T_{10}). The uptake of nitrogen observed at 45 DAS showed a similar trend as that of the uptake

Table 1. Effect of graded levels and split application of nitrogen on uptake of nitrogen at various growth stages of hybrid maize.

Treatments	30 DAS	45 DAS	60 DAS	Total uptake
T_1 - 250 kg N in 3 splits (RDN)	18.77	69.63	104.39	204.92
T_2 - 167 kg N in 3 splits (STCR)	13.75	51.49	89.98	179.68
T_3 - 225 kg N in 3 splits	17.69	67.12	101.34	195.84
T_4 - 200 kg N in 3 splits	16.29	62.69	95.87	186.96
T_5 - 175 kg N in 3 splits	15.00	57.93	92.42	182.22
T_6 - 150 kg N in 3 splits	13.18	50.28	86.01	159.23
T_7 - 225 kg N in 4 splits	16.61	63.96	106.26	222.35
T_8 - 200 kg N in 4 splits	15.26	59.67	102.43	214.16
T_9 - 175 kg N in 4 splits	14.04	53.25	97.79	198.42
T_{10} - 150 kg N in 4 splits	12.72	50.02	88.29	177.75
SEd	0.34	1.10	1.56	4.41
CD (p= 0.05)	0.71	2.29	3.27	9.27

of nitrogen registered with 30 DAS.

At 60 DAS the highest uptake of 106.26 kg/ha was registered with application of 225 kg/ha of nitrogen in four equal splits at 7 DAS, 25 DAS, 45 DAS and 60 DAS (T_7). Application of 150 kg/ha nitrogen in three splits at 7 DAS (25%), 25 DAS (50%) and 45 DAS (25%) (T_6) recorded the lowest uptake (86.01 kg/ha) among the treatments. At harvest stage, highest uptake of nitrogen was observed with the treatment where application of 225 kg/ha of nitrogen was done in four equal splits at 7 DAS, 25 DAS, 45 DAS and 60 DAS (T_7) with a value of 222.35 kg/ha. The lowest total uptake of N (159.23 kg/ha) was recorded with application of 150 kg/ha of nitrogen in three splits at 7 DAS (25%), 25 DAS (50%), 45 DAS (25%) (T_6).

Phosphorus uptake

Uptake of phosphorus (Table 2) by the hybrid maize crop at 30 DAS was highest (4.19 kg/ha) with application of 250 kg/ha of nitrogen in three splits at basal (25%), 25 DAS (50%) and 45 DAS (25%) (T_1). The lowest (2.05 kg/ha) uptake of phosphorus at 30 DAS was recorded with application of 150 kg/ha of nitrogen in four equal splits at 7 DAS, 25 DAS, 45 DAS and 60 DAS (T_{10}). The uptake of phosphorus at 45 DAS had a similar trend of results to that of the uptake registered at 30 DAS with the uptake of phosphorus varied from 7.21 to 11.88 kg/ha. At 60 DAS, the highest uptake of phosphorus (22.24 kg/ha) was associated with application of 225 kg/ha of nitrogen in four equal splits at 7 DAS, 25 DAS, 45 DAS and 60 DAS (T_7). The lowest uptake (14.16 kg/ha) was observed with application of 150 kg/ha of nitrogen in three splits at 7 DAS (25%), 25 DAS (50%), 45 DAS (25%) (T_6). The total uptake of phosphorus at harvest showed that application of 225 kg/ha of nitrogen in four equal splits at 7 DAS, 25 DAS, 45 DAS and 60 DAS (T_7) registered the highest uptake (29.27 kg/ha). The lowest uptake of phosphorus at harvest (24.37 kg/ha) was associated with application of 150 kg/ha of nitrogen in three splits at 7 DAS (25%), 25 DAS (50%), 45 DAS (25%) (T_6).

Table 2. Effect of graded levels and split application of nitrogen on uptake of phosphorus at various growth stages of hybrid maize.

Treatments	30 DAS	45 DAS	60 DAS	Total uptake
T_1 - 250 kg N in 3 splits (RDN)	4.19	13.39	21.67	27.93
T_2 - 167 kg N in 3 splits (STCR)	2.38	7.62	16.83	25.14
T_3 - 225 kg N in 3 splits	3.74	11.88	20.39	27.03
T_4 - 200 kg N in 3 splits	3.45	10.29	18.14	26.86
T_5 - 175 kg N in 3 splits	2.89	8.36	17.32	25.72
T_6 - 150 kg N in 3 splits	2.28	7.45	14.16	24.37
T_7 - 225 kg N in 4 splits	3.55	10.74	22.24	29.27
T_8 - 200 kg N in 4 splits	2.91	8.75	20.89	28.94
T_9 - 175 kg N in 4 splits	2.52	7.93	18.67	27.68
T_{10} - 150 kg N in 4 splits	2.05	7.21	16.38	24.83
SEd	0.07	0.22	0.28	0.49
CD (p= 0.05)	0.15	0.47	0.60	1.04

Potassium uptake

The observation on uptake of potassium (Table 3) at 30 DAS revealed that the highest uptake (38.19 kg/ha) was associated with the application of 250 kg/ha of nitrogen in three splits at basal (25%), 25 DAS (50%) and 45 DAS (25%) (T_1). Application of 150 kg/ha of nitrogen in four equal splits at 7 DAS, 25 DAS, 45 DAS and 60 DAS (T_{10}) registered the lowest uptake (26.88 kg/ha). The trend of results on uptake of potassium at 45 DAS followed the similar trend as that of the uptake of potassium registered at 30 DAS but with increase uptake. At 60 DAS the highest uptake of potassium (145.07 kg/ha) was registered with application of 225 kg/ha of nitrogen in four equal splits at 7 DAS, 25 DAS, 45 DAS and 60 DAS (T_7). The lowest uptake of potassium (102.36 kg/ha) among the treatments was observed with application of 150 kg/ha of nitrogen in three splits at 7 DAS (25%), 25 DAS (50%), 45 DAS (25%) (T_6). The highest uptake of potassium at harvest stage of the crop (220.28 kg/ha) was registered with the treatment of application of 225 kg/ha of nitrogen in four equal splits at 7 DAS, 25 DAS, 45 DAS and 60 DAS (T_7). Application of 150 kg/ha of nitrogen in three splits at 7 DAS (25%), 25 DAS (50%), 45 DAS (25%) (T_6) recorded the lowest uptake (159.23 kg/ha).

Table 3. Effect of graded levels and split application of nitrogen on uptake of potassium at various growth stages of hybrid maize.

Treatments	30 DAS	45 DAS	60 DAS	Total uptake
T_1 - 250 kg N in 3 splits (RDN)	38.19	88.91	142.78	208.67
T_2 - 167 kg N in 3 splits (STCR)	29.13	73.12	108.86	165.34
T_3 - 225 kg N in 3 splits	36.28	85.34	132.65	201.46
T_4 - 200 kg N in 3 splits	34.06	82.03	120.74	195.19
T_5 - 175 kg N in 3 splits	31.39	78.74	112.48	167.68
T_6 - 150 kg N in 3 splits	27.51	68.56	102.36	152.43
T_7 - 225 kg N in 4 splits	34.32	83.89	145.07	220.28
T_8 - 200 kg N in 4 splits	32.04	79.57	134.72	215.85
T_9 - 175 kg N in 4 splits	29.73	75.26	124.53	206.72
T_{10} - 150 kg N in 4 splits	26.88	65.94	104.60	161.56
SEd	0.63	1.60	3.74	3.47
CD (p= 0.05)	1.34	3.37	7.86	7.30

Table 4. Effect of graded levels and split application of nitrogen on post-harvest soil available nutrients (kg/ha).

Treatments	Nitrogen	Phosphorus	Potassium
T_1 - 250 kg N in 3 splits (RDN)	59.6	11.0	297.5
T_2 - 167 kg N in 3 splits (STCR)	190.4	12.5	338.1
T_3 - 225 kg N in 3 splits	179.2	11.7	313.5
T_4 - 200 kg N in 3 splits	182.0	12.0	325.9
T_5 - 175 kg N in 3 splits	187.6	12.1	330.4
T_6 - 150 kg N in 3 splits	198.8	13.4	361.8
T_7 - 225 kg N in 4 splits	151.2	10.2	272.1
T_8 - 200 kg N in 4 splits	154.0	10.9	290.7
T_9 - 175 kg N in 4 splits	173.6	11.3	302.4
T_{10} - 150 kg N in 4 splits	196.0	12.9	349.5
SEd	3.1	0.3	6.0
CD (p= 0.05)	6.6	0.6 12.6	

Post-harvest soil available nutrients

Available nitrogen

The highest post-harvest status of available NP-K(XXXX, YYYY, ZZZZ) was registered with application of 150 kg/ha of nitrogen in three splits at 7 DAS (25%), 25 DAS (50%), 45 DAS (25%) (T_6). The lowest NPK was associated with application of 225 kg/ha of nitrogen in four equal split at 7 DAS, 25 DAS, 45 DAS and 60 DAS (T_7) (Table 4).

Economic

Cost of cultivation

The highest cost of cultivation of Rs 56028/ha was registered with application of 250 kg/ha of nitrogen applied in three splits at basal (25%), 25 DAS (50%) and 45 DAS (25%) (T_1). The lowest cost of cultivation of Rs 54260/ha was worked out with application of 150 kg/ha of nitrogen in three splits at 7 DAS (25%), 25 DAS (50%) and 45 DAS (25%) (T_6) (Table 5).

Gross return, net return and B:C ratio

The highest gross return (Rs 139802/ha) and net return (Rs 84080/ha) and benefit cost ratio (2.51) were calculated with 225 kg/ha of nitrogen applied in four equal splits at 7 DAS, 25 DAS, 45 DAS and 60 DAS (T_7). The lowest gross return (Rs 121503/ha) and net return (Rs 67243/ha) and B:C ratio (2.24) were associated with application of 150 kg/ha of nitrogen in three splits at 7 DAS (25%), 25 DAS (50%) and 45 DAS (25%) (T_6).

DISCUSSION

Nutrient uptake

The uptake of nitrogen increased linearly from sowing to harvest. The total uptake of nitrogen was higher with 225 kg/ha of nitrogen applied in four splits. Increased uptake of nitrogen at higher doses might be due to high availability of soil available N to crop growth. This could have resulted in better uptake of nutrients initially favoring vigorous growth combined with high photosynthetic rate led to better uptake through the crop growth period.

Table 5. Effect of graded levels and split application of nitrogen on economics of hybrid maize.

Treatments	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
T_1 - 250 kg N in 3 splits (RDN)	56028	136650	80622	2.44
T_2 - 167 kg N in 3 splits (STCR)	54470	126456	71986	2.32
T_3 - 225 kg N in 3 splits	55186	134255	79069	2.43
T_4 - 200 kg N in 3 splits	54874	131402	76528	2.39
T_5 - 175 kg N in 3 splits	54567	127497	72930	2.34
T_6 - 150 kg N in 3 splits	54260	121503	67243	2.24
T_7 - 225 kg N in 4 splits	55722	139802	84080	2.51
T_8 - 200 kg N in 4 splits	55410	138743	83334	2.50
T_9 - 175 kg N in 4 splits	55103	135456	80353	2.46
T_{10}- 150 kg N in 4 splits	54796	126146	71350	2.30

When a considerable amount of N was applied at or near anthesis period, there is a greater possibility of its accumulation in sink rather than other vegetative parts. Moreover, split application of nitrogen decreases the nitrogen losses (through leaching and volatilization) and could have resulted in better utilization, which reflected in the uptake of N. Also, under the conditions of delayed split application of nitrogen, the crop had a good chance to take their nutritional requirements in an easy way (Aiad *et al.* 2014). These results are in accordance with those obtained by Giuliani *et al.* (2011), Beshara (2012).

The high phosphorus and potassium uptake was due to increased growth and dry mater production with the application of nitrogen and also due to increased nitrogen uptake. This was in line with the findings of Parthipan and Prem (2002). Application of increased potassium uptake with synergetic effect of nitrogen rate was also due to increased dry mater production caused by higher nitrogen rate.

Economics

The economic analysis of hybrid maize indicated that different doses and split applications of nitrogen substantially influenced all the economic parameters. In the present study increased split application of nitrogen for the same level of nitrogen increased the cost of cultivation marginally due to increased labor cost alone. But the increased yield due to increased split application was large enough and it increased the gross return and thus net return and B:C ratio. In case of application of N at 250 kg/ha it recorded the highest cost of cultivation due to the increased cost of N by 25 kg as compared to application of 225 kg/ha. However, the increased split application favored for more yield and thus increased the gross return, net return and finally the B:C ratio. Hence, in all these cases, increased cost due to increased in number of split application was marked by higher returns due to increased yield.

CONCLUSION

The results obtained from the present study shows that at 30, 45 DAS higher plant nutrient uptake of NPK was with the application of 250 kg/ha in 3 splits at basal (25%), 25 DAS (50%) and 45 DAS (25%) (T_1). Whereas at 60 and harvest the treatment with application of 225 kg N/ha in 4 equal splits at 7 DAS, 25 DAS, 45 DAS, 60 DAS (T_7) register higher uptake. Similarly for post-harvest soil available nutrients (NPK) T_6 showed better results. On economics the cost of cultivation was high with T_1, whereas gross return, net return and B : C ratio was higher with T_7. With this it is evident that the treatment T_7 significantly reduced the nitrogen usage and loss without compromising much of productivity. Thereby it is concluded from the study that the 225 kg N/ha in 4 equal splits at 7 DAS, 25 DAS, 45 DAS, 60 DAS is the optimum split and dosage for achieving better plant nutrient uptake and economics from hybrid maize.

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REFERENCES

Aiad MA, Moursi EA, El-Dissoky RA, Amer MM (2014) Response of maize crop to irrigation under different rates and doses of nitrogen fertilization in the North Nile delta region. *J Soil Sci Agric Engg Mansoura Univ*. 5 (1) : 97—113.

Beshara AT (2012) Effect of soil moisture depletion and nitrogen fertilizer application date on wheat yields, water and fertilizer use efficiencies in North Africa. PhD. thesis. Institute of African Research and Studies. Cairo Univ.

Giuliani MM, Giuzio L,Caro A, Flagella Z (2011) Relationships between nitrogen utilization and grain technological quality in durum wheat 1-nitrogen translocation and nitrogen use efficiency for protein. *Agron J Am Soc. Agric USA* 103 (5) : 1487—1494.

Hassan SW, Oad FC, Tunio S, Gandahi AW, Siddiqui MH, Oad SM, Jagirani AW (2010) Effect of N application and N splitting strategy on maize N uptake, biomass production and physio-agronomic characteristics. *Sarhad J Agric*. 26 (4) : 551—558.

Humphries EC (1956) Mineral Component and ash analysis. In: Modern methods of plant analysis, Springer Verlag, Berlin pp 468—502.

India Maize Summit'15, 2016, IFCC and NCDEX.

Jackson ML (1973) Soil chemical analysis, Prentice Hall of India Pvt Ltd, New Delhi. 2nd Indian Reprint, pp 1—498.

Muthukumar VB, Velayudham K, Thavaprakaash N (2005) Growth and yield of baby corn (*Zea mays*) as influenced by plant growth regulators and different time of nitrogen application. *Res J Agric Biol Sci.*1 (4) : 303—307.

Olsen SR, Cole CV, Watanabe FS, Dean LA (1954) Estimation of available phosphorus in soil by extraction with sodium bicarbonate. USDA Circ, pp 939.

Parthipan T, Prem MS (2002) Yield and nutrient uptake of hybrid maize as influenced by levels and times of nitrogen fertilization. *J Agric Resour.Manag* 1 (3) : 145—149.

Sangoi L, Paulo RE, Paulo R F D (2007) Maize response to nitrogen fertilization timing in two tillage systems in a soil with high organic matter content. *R Bras Ci Solo* 31: 507—517.

Stanford SL, English L.(1949) Use of flame photometer in rapid soil tests for K and Ca *Agron. J* 41: 446—447.

Subbiah BV, Asija GL.(1956) A rapid procedure for the estimation of available nitrogen in soil. *Curr Sci* 25 : 259—260.

United States Department of Agriculture (USDA) (2017) World Agricultural Production, Circular Series; WAP 03-17, March 2017.

Walsh OS (2006) Effect of delayed nitrogen fertilization on corn grain yields. MSc thesis. Graduate College. Oklahoma State Univ, Oklahoma.