Nitrogen Levels and its Split Application Influence on Leaf Area Index (LAI), Crop Growth Rate (CGR), and Grain Yield of Spring Maize under Tillage System

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Abstract

A field study was conducted during 2012 (feb-july) to determine nitrogen level and its spilt application influence on leaf area index, crop growth rate and grain yield of spring maize under tillage systems in split-split plot design, taking tillage system (zero and conventional) as main factor, nitrogen levels (60, 120 and 180 kg N ha^{-1}) as sub plots while its split application (2 equal split and 4 equal split) was assigned as sub - sub plot. Leaf area index, crop growth rate and grain yield were not influenced by the tillage, but increased with increasing N levels and its split application. Leaf area index, crop growth rate and grain yield were highest at 180 kg N ha^{-1} than 120 kg N ha^{-1} and 60 kg N ha^{-1} applied plots. Similarly, these parameters were higher in four equal split applications than two equal split application of nitrogen. Application of 180 kg N ha^{-1} and its four equal split application increased leaf area index and crow growth rate enhancing grain yield of maize in both tillage systems.

Keyword:
Tillage; Nitrogen; Split; Leaf Area Index; Crop Growth Rate; Grain Yield

Introduction

Maize is used as human consumption in the hills and livestock feeds in the inner and inner terai of Nepal. But, production and productivity of maize lack behind to meet demand of country. High cost of cultivation, inadequate and improper use of fertilization is major limitations for low production of maize in Nepal. To reduce the cost of cultivation, farmers and researchers are adopting alternative tillage method. Zero tillage has low cost of cultivation but similar or exceed yield return as compare to conventional tillage. Maize is an exhaustive crop and requires high quantities of nitrogen. Most limiting nutrient, Nitrogen (Uribelarrea *et al*., 2009) can reduce grain yield by restricting growth and development of plant (Uhart and Andrade, 1995a). Nitrogen plays imperative role in increasing leaf area, accordingly crop growth rate and grain yield of maize by intercepting and burning up of solar radiation and. Leaching and denitrification can be reduced when fertilizer is applied during peak N demand (Keeny, 1982). Inappropriate use of nitrogen at critical stage reduces the nitrogen use efficiency, decreasing green leaf area and dry matter accumulation. Optimum doses of N at critical stages (Gangula *et al.,* 2003) are utmost necessary for better N efficiency. Nitrogen application in splits attribute to higher leaf area, dry matter accumulation (Harikrishna *et al*., 2005) and maize grain yield as than to sole application. Nitrogen rates have been amplified to 25% to counteract effect on grain yield from immobilization in zero tillage (Randall and Bandel, 1991). Strategies like split and small basal application are considered as effective for decreasing nutrient leaching (Sitthaphanit *et al*., 2009). When plant is small, split application reduces nutrients supplied and increases supply later on high crop demand. Fertilization with suitable rate and time by split increases leaf area, dry matter accumulation, and finally yields (Roberts, 2008) by coinciding nitrogen availability with crop demands. Thus experiment was, intended to test tillage system, N levels and its split application timing on leaf area index, crop growth rate and yield of maize.

Materials and Methods

Site Description

Field experiment was conducted at Phulbari VDC, Chitwan, Nepal during 2012 (Feb-July), situated at $27^0 37'$ N & $84^0 25'$ E with elevation of 256 masl. Soil was sandy loam in texture, having slightly acidic pH (5.8), organic matter (2.84), total nitrogen (0.12), available phosphorus (55.43 kg ha^{-1}), and available potassium (197.97 kg ha^{-1}).

Experimentation

The experiment was laid out in split-split plot design consisting 12 treatments with three replications. Treatments comprised of two tillage systems (conventional and zero tillage) as main factor, three nitrogen rates (60, 120 and 180 kg N ha^{-1}) as sub plots and spilt application of Nitrogen (two equal split at basal & 45 DAS and four equal split at basal, 30, 45 & 60 DAS) as sub sub plot. Maize variety Bioseed Raj Kumar was planted at the spacing of 60 × 25 cm^2 (RR to PP). Maize crop was fertilized with 60/120/180:60:40 NPK kg ha^{-1} through urea, SSP and MOP. The sowing was done on 28th February, 2012. Thinning on 25 DAS was done to maintain single plant per hill. Weeding cum inter culture was done at 25 and 55 DAS. Crop was irrigated at grand growth stage, tasseling stage and milking stage respectively. The crop from net plot area was harvested on 15th July, 2012. Data were collected on leaf area index, crop growth rate at various stages and grain yield. Leaves from selected plants were detached from near the node and leaves are passed through automatic leaf area meter (Model 3100 Area Meter) to record the leaf area in cm^2. Leaf area index was calculated by dividing leaf area per plant by spacing used by the one plants.

$$\text{Leaf area index} = \frac{\text{Leaf area/plant}}{\text{Ground area/plant}}$$

After the measurement of leaf area, detached leaves and stem of plant were ruptured and then packed in the envelope and dried in hot oven for 48 hours at the temperature of 105^0C to get a constant weight for recording the periodic dry matter accumulation.

CGR = (W2-W1) / (T2-T1), where W1 and W2 were the total dry weights of harvested sample at times T1 and T2 respectively

Statistical Analysis

Data and mean were analyzed by MSTAT-C package at 5% level of significance.

Results and Discussion

Leaf Area Index

Leaf area index (LAI) is main determining factor for light interception, affecting transpiration, photosynthesis and dry matter accumulation. The mean LAI of the experiment was 0.25 at 30 DAS, which increased to maximum 2.55 at 75 DAS and then began to decline and reached 1.20 at 105 DAS (Table 1). The decline of LAI after 75 DAS was due to the reduction in leaf extension rate, cessation of the development of new leaves and enhanced leaf senescence after the tasseling stage of the crop. The effect of tillage on LAI of the maize was non-significant at all dates of observation (Table 1). But numerically higher LAI was observed in CT than ZT at all dates of observation. This result was in agreement Wilhelm *et al*. (1991), who found that there was no affect of conventional tillage and zero tillage on LAI of maize. LAI increased with increasing of nitrogen levels from 60 kg ha^{-1} to 180 kg ha^{-1}. Nitrogen application of 180 kg ha^{-1} had significantly more LAI than 120 and 60 kg ha^{-1} N application at all dates of observation. Application of 180 kg N ha^{-1} resulted highest LAI (3.37) at 75 DAS. The LAI at 45 DAS was observed at par with both 120 and 180 kg ha^{-1} N application. Shanti *et al*. (1997**)** and Asim *et al*. (2012) reported that LAI of maize crop increased with increasing nitrogen levels. Four equal split application of N significantly enhanced LAI than two equal split application of N at 45, 60, 75, 90 and 105 DAS except 30 DAS. Nitrogen increases chlorophyll content of plant by affecting cell and tissue growth, thereby enhanced leaf area, leaf number and photosynthetic efficiency. Nitrogen (Eltelib *et al*. 2006) and split of N promotes plant growth, enhancing leaf expansion and development. There was non-interaction among tillage, nitrogen level and split application of N on LAI at all dates of observation (p>0.05).

Crop Growth Rate (CGR)

Crop growth rate is the dry matter accumulation of the crop per unit land area in unit of time and expressed as g m^{-2} d^{-1}. The mean CGR in the experiment was observed 1.39, 4.04, 11.28 and 4.87 g m^{-2} day^{-1} at 30-45, 45-60, 60-75, and 75-90 DAS respectively (Table 2). CGR increased at every 30-45, 45-60, 60-75 but decreased at 75-90 DAS. CGR was higher but significantly not different in CT than ZT day^{-1} at 30-45, 45-60, 60-75, and 75-90 DAS respectively. CGR was significantly influenced by the nitrogen levels at all dates of observation except 75-90 DAS. CGR was observed increasing with increasing dose of N from 60 to 180 kg ha^{-1} N application. The maximum CGR in 180 kg N ha^{-1} at 60-75 DAS as compared to 120 and 60 kg N ha^{-1} and similar trend was observed at 30-45 and 45-60 DAS respectively. CGR increased at fast rate up to 75 DAS and thereafter decrease at faster rate to harvest. CGR of maize significantly differ at the vegetative stage, while CGR of maize had no significant difference during the grain filling (Chung *et al*. 2000). CGR was significantly higher in four equal split application of N than two equal split application of N at all date of observation except 75-90 DAS. High rate of N and split application of N up to later stage of maize increased growth because of optimum and timely availability of N which increased photosynthetic activity of maize leading to biomass $plant^{-1}$ and increased CGR. There was non-significant interaction among tillage, nitrogen level and split application of N on crop growth rate accumulation at 30-45, 45-60, 60-75 and 75-90 DAS (p>0.05).

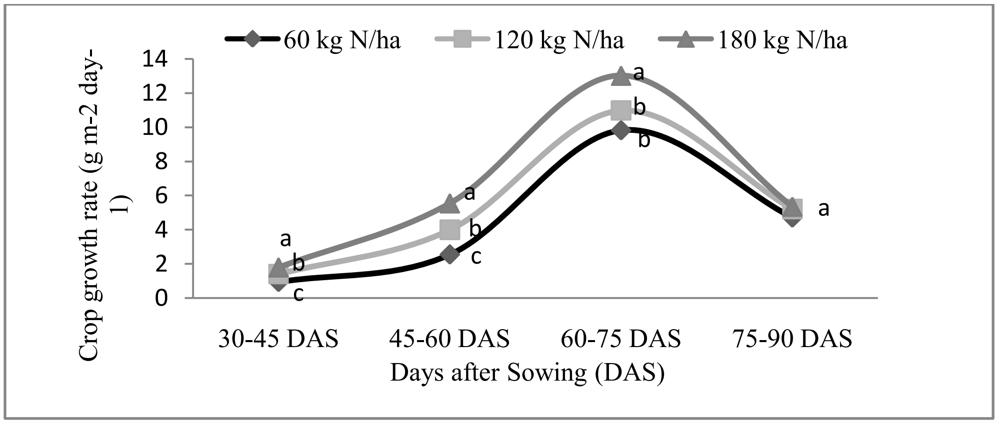

Figure 1. Effect of Nitrogen level on Crop Growth Rate on Spring Maize at Phulbari, Chitwan, 2012

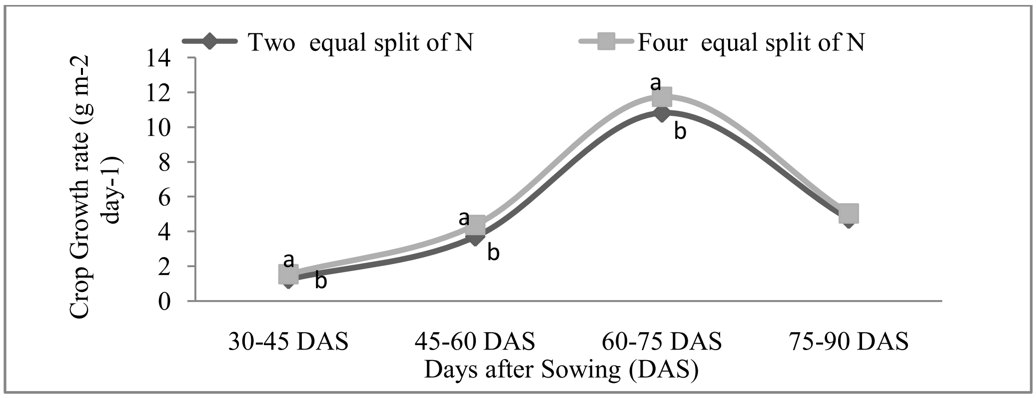

Figure 2. Effect of Split Application of Nitrogen on Crop Growth Rate of Spring Maize at Phulbari, Chitwan, 2012

Table 1. Effect of Tillage, Nitrogen level and Split Application of Nitrogen on Leaf Area Index of Spring Maize at Phulbari, Chitwan, 2012

Treatments	Leaf area index (cm^2)					
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS
Tillage						
Conventional	0.26	0.66	1.92	2.59	1.83	1.23
Zero	0.25	0.65	1.86	2.51	1.77	1.18
LSD	NS	NS	NS	NS	NS	NS
SEm±	0.002357	0.007454	0.02108	0.02887	0.1826	0.01667
Nitrogen Level						
60 kg/ha	0.16 [c]	0.42 [b]	0.85 [c]	1.56 [c]	0.84 [c]	0.32 [c]
120 kg/ha	0.27 [b]	0.71 [a]	1.86 [b]	2.70 [b]	1.90 [b]	1.27 [b]
180 kg/ha	0.32 [a]	0.83 [a]	2.96 [a]	3.37 [a]	2.65 [a]	2.02 [a]
LSD	0.009414	0.1227	0.1331	0.1547	0.1364	0.06657
SEm±	0.002887	0.03764	0.04082	0.04743	0.04183	0.02041
Split Application of Nitrogen						
Two equal	0.25	0.64 [b]	1.84 [b]	2.45 [b]	1.74 [b]	1.14 [b]
Four equal	0.26	0.68 [a]	1.94 [a]	2.65 [a]	1.86 [a]	1.26 [a]

LSD	NS	0.03978	0.09469	0.1894	0.1171	0.1077
SEm±	0.002357	0.01291	0.03073	0.06146	0.03801	0.03496
CV%	5.26%	8.97%	6.95%	10.20%	9.04%	12.46%
Grand mean	0.254	0.654	1.890	2.550	1.798	1.202

Means followed by the common letter within each column are not significantly different at 5% level of significance by DMRT. Days after sowings (DAS), Non-significant (NS)

Table 2. Effect of Tillage, Nitrogen level and Split Application of nitrogen on Crop Growth Rate (CGR) and Grain Yield of Spring Maize at Phulbari, Chitwan, 2012

Treatments	CGR (g m^{-2} day^{-1})				
	30-45 DAS	45-60 DAS	60-75 DAS	75-90 DAS	Grain Yield (ton/ha)
Tillage					
Conventional0	1.42	4.09	11.29	4.94	7.53
Zero	1.36	3.98	11.27	4.82	7.37
LSD	NS	NS	NS	NS	NS
SEm±	0.01667	0.04346	0.0882	0.05821	0.03162
Nitrogen Levels					
60 kg/ha	0.94^{c}	2.55^{c}	9.82^{b}	4.71	5.29^{c}
120 kg/ha	1.41^{b}	4.0^{b}	10.98^{b}	5.21	8.15^{b}
180 kg/ha	1.81^{a}	5.56^{a}	13.03^{a}	5.36	8.91^{a}
LSD	0.3206	0.9932	1.615	NS	0.4910
SEm±	0.09832	0.3045	0.4953	0.3844	0.1506
Split Application of Nitrogen					
Two Equal	1.25^{b}	3.70^{b}	10.82^{b}	4.72	7.22^{b}
Four Equal	1.54^{a}	4.37^{a}	11.74^{a}	5.03	7.68^{a}
LSD	0.2117	0.5778	0.8214	NS	0.3521
SEm±	0.06872	0.1875	0.2666	0.1333	0.1143
CV%	20.89 %	19.71 %	10.03 %	11.61 %	9.50 %
Grand mean	1.39	4.04	11.28	4.88	7.45

Means followed by the common letter within each column are not significantly different at 5% level of significance by DMRT. Days after sowings (DAS), Non-significant (NS)

Grain Yield

Grain yield (tha^{-1}) was not significantly affected by tillage systems. However, higher grain yield was obtained in CT (7.53 t ha^{-1}) as compared to ZT (7.37 t ha^{-1}). Grain yield was non-significant between two tillage as there was no significant difference in biometric characters like leaf area index and crop growth rate. Similar result was also found by Wilhelm *et al*. (1991) and also reported no grain difference between no tillage and conventional tillage. Increasing Nitrogen levels from 60 to 180 kg ha^{-1} increased the grain yield. 180 kg ha^{-1} N application produced grain yield (8.91 t ha^{-1}) which was significantly higher than 120 (8.15 t ha^{-1}) and 60 kg ha^{-1} N application (5.29 t ha^{-1}). More number of leaves per plant, higher LAI and dry matter accumulation at all stages might be responsible for higher yield at increasing N levels. Wasaya *et al*. 2011 and Dahal *et al*. 2011 reported that grain yield increased with increasing nitrogen levels. Four equal split application of N produced higher grain yield (7.68 t ha^{-1}) than grain yield (7.22 t ha^{-1}) from two equal split application of N. The four equal split application of N significantly improved LAI and dry matter accumulation resulting in higher grain yield of maize than the two equal split application of N. Four time times split of N significantly increased the grain yield than two times split (Sitthaphanit *et al*. 2009). The non-significant interaction among tillage, nitrogen level and split application of N on grain yield ($p>0.05$).

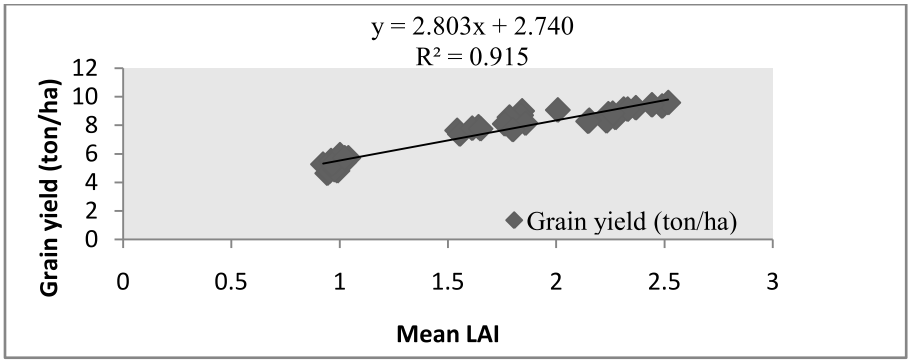

Figure 3: Relation between Grain Yield and Mean Leaf Area Index (LAI) on Spring Maize at Phulbari Chitwan, 2012

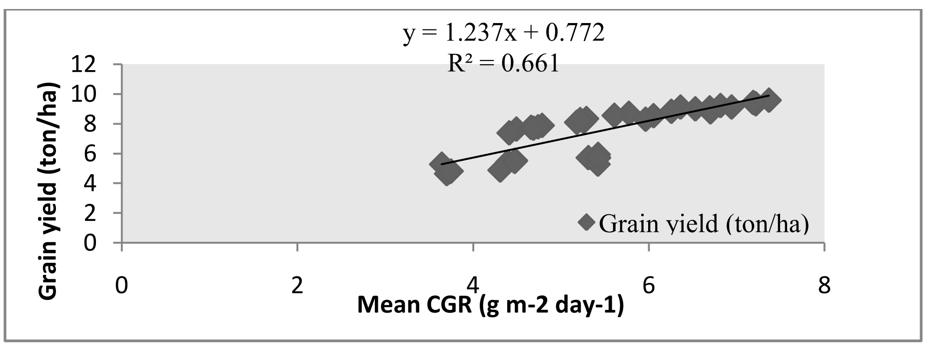

Figure 4: Relation between Grain Yield and Crop Growth Rate (CGR) on Spring Maize at Phulbari Chitwan, 2012

Grain yield strongly correlated with leaf area index and crop growth rate. The correlation coefficient of grain yield with mean LAI and Mean CGR was linear and positive ($R^2 = 0.91$ and 0.66; Fig. 3 and Fig. 4 respectively). According to the coefficient of determination, about 91.55 % and 66.17 % variations in grain yield in maize due to leaf LAI and CGR respectively, remaining portion due to other factors. Grain yield of maize had positive relationship with parameters like TDM production, LAI and CGR (Otegui and Andrade, 2000). Variation in grain yield with nitrogen and its spit application was due to significant difference in growth parameter like TDM production, LAI and CGR values. Consequently, these difference lead to significant change in the grain yield.

Conclusion

Leaf area index, crop growth rate and grain yield were not influenced by tillage system. Nitrogen and its split application influenced LAI, CGR and grain yield. LAI, CGR and grain yield were maximum in 180 kg N ha^{-1} than 120 and 60 kg N ha^{-1} application. Four equal split application of N concluded in higher LAI, CGR and grain yield than two equal split application of N. Moreover, the correlation analysis explicated that the grain yield was highly and positively associated with parameter LAI and CGR.

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