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International Journal of Current Research
Vol. 8, Issue, 07, pp.33894-33900, July, 2016

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

EFFECT OF PRECEDING CROPS AND NITROGEN RATES ON CROP GROWTH INDICES OF WINTER HYBRID MAIZE (*ZEA MAYS* L.)

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ARTICLE INFO

Article History:
Received 21st April, 2016
Received in revised form
10th May, 2016
Accepted 14th June, 2016
Published online 16th July, 2016

Key words:

Preceding crop,
Nitrogen,
Summer legumes crop,
Inclusion,
Crop sequence.

ABSTRACT

A field experiment was conducted at Agronomy research farm of IAAS, Rampur, chitwan, Nepal during summer and winter season 2010 and 2011 to study the effect of crop sequence and nitrogen rates on hybrid maize. There were thirty treatment combination consisting of six crop sequences, maize-maize, fallow-maize, greengram-maize, cowpea-maize, blackgram-maize, clusterbean-maize in main plots and five nitrogen rates 0, 50, 100, 150, 200 kg/ha in subplots with three replication. The research finding revealed that Maximum number of cobs (61,200/ha in 2010 and 61,900/ ha in 2011) was recorded under blackgram –maize sequence which was comparable to number of cobs/ha under greengram-maize while it was minimum under maize-maize sequence during both the years. Number of cobs was maximum 66,200/ha in 2010 and 67,200/ha 2011 with 200kg/ha and it was minimum under no nitrogen application. Percentage of barren plants was minimum (11.7 in 2010 and 11.5 in 2011) under blackgram-maize sequence which was comparable to greengram –maize sequence, while maximum percentage of barren plants was recorded under maize-maize sequence. Minimum percentage of barren plants (5.6 in 2010 and 6.2 in 2011) was recorded with 200kgN/ha and it was maximum under no nitrogen application. Minimum number of days to silking (54 .7 in 2010 and 53.3 in 2011) was recorded under greengram– maize sequence while it was maximum (57.3 in 2010 and 55 .8 in 2011) under maize–maize sequences. Number of days to silking was minimum (53.1 in 2010 and 52 .1 in 2011) with 200 kg N/ha while it was maximum (60 .6 in 2010 and 59 .1 in 2011) under no nitrogen application. At maturity (90 days after sowing), maximum dry matter accumulation per plant (174.7 g in 2010 and 176.0 g in 2011) was recorded under greengram– maize sequences and it was minimum under maize– maize sequences. It was maximum (206.0 g in 2010 and 207.2 g in 2011) with 200kg N/ha minimum with no nitrogen. At maturity (90 DAS) maximum plant height (170.7 cm in 2010 and 173.9 cm in 2011) under greengram– maize sequences while it was minimum under maize– maize. At maturity (90 DAS) maximum plant height (169.2 cm in 2010 and 173.1 cm 2011) was recorded with 200 kg N/ha while it was minimum with no nitrogen application. At silking stages (60 DAS) maximum leaf area index (3.39 in 2010 and 3.45 in 2011) was recorded under greengram – maize sequences and it was minimum under maize – maize. At silking stage (60 DAS) leaf area index was maximum (3.86 in 2010 and 3.72 in 2011) with 200 kg N/ha while it was minimum with no nitrogen application.

Citation: Yadav, B. P., Yadav, D. N., Koirala, K. B., Pandey, K. R. and Thapa, R. B. 2016. "Effect of preceding crops and nitrogen rates on crop growth indices of winter hybrid maize (*Zea mays* L.)", *International Journal of Current Research*, 8, (07), 33894-33900.

INTRODUCTION

Winter maize has got highest production potential among the crop plants and due to wide variability in plant morphology; it has extremely wider adaptability also. It is more efficient than rice, wheat, barley. It is a heavy feeder of fertilizer nutrients particularly nitrogen, its effect being manifested quickly on plant growth and productivity. Among cereals, Maize is an important food and feed crops which rank second after rice and then wheat where as in global context it ranks third after wheat and rice. It is the second most important staple food crop both in terms of area and production after rice in Nepal. It is grown in 8, 70,166 hectare of land with an average yield of 2159 kg/ha. It occupies about 28.15% of the total cultivated agricultural land. Winter maize has an important place

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amongst the winter crops of the country and the other crops are wheat, gram, lentil, pea etc, under upland rainfed condition summer maize, green gram, black gram, cowpea, cluster bean are grown in rainy season and after the harvest of these crops during winter wheat, lentil, gram, mustard and winter maize are grown. The history of hybrid maize development is not very old in Nepal (Sherchan, *et al*., 2004). Research work on hybrid maize was initiated by National Maize Research Program (NMRP) during 1987 and the systematic work was done and expanded to different research stations of National Agricultural Research Council (NARC) both in terai and hill research stations to develop conventional hybrids (Gurung *et al.*, 2007). Maize being C_4 plant is called photosynthetically most efficient plant in general among cereal and among three season of maize i.e winter, spring season and rainy season. Winter maize is physiologically, biotic and abiotic point of view is most efficient. Hence, from maximum production point of view winter maize is top most among winter season crops i.e. wheat, barley and others. Although maize is grown in all seasons i.e. spring, rainy and winter season, the productivity of winter maize is much higher than other season maize (Sherchan *et al.,* 2004) For many crop plants of temperate zone, optimum temperature for photosynthesis is lower than that for respiration, This has been suggested as one of the reasons for the higher yields of starchy crops such as maize and potatoes in cool climates as constrained with the yield of these crops in warmer region. Inner terai winter season temperature is favourable for photosynthesis than respiration during period of winter maize. For best growth, mean day temperature is 24 ^{o}C which is likely to be available for maize in winter season rather than other season i.e. spring and rainy season.

Maize-wheat and Maize-toria is widely adopted crop sequence and more popular under upland conditions. Besides the higher production potential for grain, higher amount of feed and fodder is also obtained under this sequence. But the continuous adoption of this sequence on same piece of land may have adverse effect on physical, chemical and biological properties of soil as continuous cropping of cereals impoverish yield of succeeding crops but inclusion of legumes in the rotation benefits the succeeding crops (Bains 1962). Roy Sharma and Singh (1970) observed significantly greater plant height of maize when grown after berseem, sweet clover and peas, as compared to maize grown after fallow. Patel (1980) observed positive effect on plants height and dry weight of maize following legumes compared with that after wheat of maize following legumes compared with that after wheat. Maize following grains legumes i.e. gram, lentil , pea, attained significantly more plant height i.e. 155, 153, 152, cm as compared to 139 and 144 cm after wheat and fallow respectively (Ahlawat *et al*., 1981) . Ramteke *et al.* (1985) reported maximum dry matter production of maize grown after berseem, intermediate after gram, peas and lentil but lowest after wheat. In dry land cropping system study preceding crops either ground nut, cowpea or pigeon pea were found to increase the early seeding vigour and rate of plant growth of subsequent pearlmillet (Giri and De, 1980). In terms of plant height and dry matter accumulation wheat grown after cowpea was superior to that grown after maize (Velayudham and Seth, 1986). Harikrishna *et al*. (2005). Reported that effect of soil depths, N – doses and its split application on maize increase plant height, LAI and dry matter yield at different growth stages. Nitrogen is very essential for good vegetative growth and grain development in maize production (Adediran *et al*., 1995). The increased plant height with increasing levels of nitrogen was recorded by Muthukrishnan and Subramanian (1980). Plant height and leaf area index in winter maize increased with increasing levels of nitrogen application upto 100 kg ha^{-1} (Prasad *et al.,* 1985).

The maximum growth rate at 150 DAS with 200 kg N ha^{-1} in winter maize was reported by Nandal and Agarwal (1991). Leaf growth, leaf appearance and photosynthetic capacity in maize increased with higher levels of N fertilizer (Vos *et al.,* 2005). Nitrogen deficiency in corn delays the development of ears relative to the tassel and may thus affect the coincidence of pollen shed and silking of individual spikelets (Jacob and Pearson, 1991). Nitrogen is the most limiting nutrient for maize production. Maize is an exhaustive crop and requires high quantities of nitrogen. The practice of fertilizer recommendation on the basis of individual crop is becoming less relevant because individual crop is a component of cropping system and cannot be grown in isolation. Therefore fertilizer recommendation should be made by giving due considerations to nature of preceding crops or in other words the cropping system as a whole besides the soil condition.

MATERIALS AND METHODS

Field experiment under upland ecosystem was conducted in split plot design with three replications at Institute of Agriculture and Animal Science (IAAS) Agronomical research farm Rampur, Chitwan during 2010 and 2011, keeping crop sequence in main plots and nitrogen rates to maize in sub plots. The main plots treatments consisted six crop sequence i.e. fallow-maize, Maize-maize, green gram-maize, cowpea - maize, black gram-maize, cluster bean-maize. The sub-plot treatment consisted five nitrogen rates to maize i.e. 0, 50, 100, 150 and 200 kg N/ha. Experiment was laid down in a split plot deign with thirty treatment and three replications. The soil of the experimental field was free from any kind of salinity/sodicity hazards. Soil was suitable to variety of crops of tropical and subtropical regions. Soil was loamy sandy soil with neutral PH (7.0). The climate of the experimental farm was characterized as subtropical humid.

Growth and development characteristic of different summer legumes crops was studied along with Rajkumar, Indian hybrid maize, variety sown at row to row distance 60 cm and plant to plant 20 cm, popularly grown in Chitwan and terai region of Nepal which is a semi-dent and orange flint type possess relatively longer ear with high disease resistant and responsive to fertilizer and water.

Different growth parameters of maize i.e. plant height, dry matter accumulation and Leaf area index were calculated from 30 DAS, days to tasseling and days to silking, plant stand, barrenness percentage and cob number were taken for the biometric observation of hybrid maize and statistical analysis was done.

RESULTS AND DISCUSSION

Crop growth indices

Productivity of summer legumes crops

Before presenting the results pertaining to maize crop, a general performance of the crops of different crop sequences is studied. The mean grain and straw yield of greengram, cowpea and blackgram was higher in 2011 than 2010 (Table 1). Similarly, yield components i.e. number of pods per plant and 1000 grain weight in greengram, cowpea and blackgram was higher in 2011 than 2010. (Table 2) However, grain number per pod and grain to straw ratio was comparable during both the years. In maize, grain yield was more in 2011 than 2010. But straw yield was less in 2011 than 2010. Consequently grain to straw ratio was more in 2011 than 2010. Number of pods per plant, grain number per pod and 1000 grain weight was identical during both the years. Maize in both the sequences i.e. maize – maize and fallow – maize had higher grain and straw in 2011 than 2010. (Table 1)

Table 1. Yield components and yield of summer crops

Greengram

N. rates to Maize	Pods no./ plants		Grain no./ pod		1000- grain weight (g)		Grain yield kg/ha		Straw yield kg /ha		Grains : straw ratio	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
N_0	34.2	34.0	11.8	11.4	30.1	30.6	699	700	3067	3667	0.42	0.36
N_{50}	33.2	36.2	11.26	11.7	32.2	30.0	700	720	3784	3984	0.34	0.36
N_{100}	37.2	37.2	11.70	11.4	32.6	34.0	720	750	3356	3898	0.35	0.34
N_{150}	37.5	39.3	11.60	11.7	33.0	34.2	738	770	3548	3780	0.37	0.37
N_{200}	38.8	38.9	11.80	11.8	34.2	34.2	740	780	3590	3790	0.38	0.39
Mean	36.4	37.9	11.70	11.7	34.2	34.5	750	760	3445	3833	0.37	0.36

Clusterbean

N rates to Maize	Pods no ./ plants		Grain no./ pod		weight of pods per plant (g)		Green pod yield T/ha		Dry weight of green pod T/ha		Biological yield T/ha	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
N_0	9.80	10.20	41.00	41.20	83.40	86.30	4.90	4.80	1.50	1.90	5.00	5.30
N_{50}	10.30	10.50	43.20	43.30	85.77	88.90	5.30	5.40	1.60	1.80	5.44	5.66
N_{100}	10.50	10.50	44.30	44.50	87.80	91.00	6.55	6.60	1.80	2.00	5.90	5.99
N_{150}	11.80	12.20	48.90	49.90	90.12	92.99	7.00	7.30	2.00	2.30	6.80	6.90
N_{200}	11.85	12.30	50.50	50.60	95.30	93.70	7.66	7.50	2.12	2.22	7.00	7.30
Mean	11.75	12.20	50.40	50.50	95.20	93.50	7.65	7.40	2.10	2.20	7.10	7.20

Blackgram

N rates to maize	Pods o n./ plants		Grain no./ pod		1000- grain weight (g)		Grain yield kg/ha		Straw yield kg /ha		Grains : straw ratio	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
N_0	41.5	41.9	12.5	12.9	34	35	740	750	3067	3667	0.42	0.36
N_{50}	42.1	42.0	13.0	13.2	33	36	780	790	3784	3984	0.34	0.36
N_{100}	44.4	44.8	13.1	13.4	36	37	800	820	3356	3898	0.35	0.34
N_{150}	45.3	45.5	13.2	13.6	36	40	810	840	3548	3780	0.37	0.37
N_{200}	46.3	46.8	13.4	13.5	37	38	820	850	3590	3790	0.38	0.39
MEAN	45.2	45.3	13.0	13.4	38	39	800	820	3445	3833	0.37	0.36

Cowpea

N rates to Maize	Pods no ./ plants		Grain no./ pod		1000- grain weight (g)		Grain yield kg/ha		Straw yield kg /ha		Grains : straw ratio	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
N_0	18.2	18.5	8.0	8.1	62	63	750	750	3067	3667	0.42	0.36
N_{50}	18.5	19.8	8.2	8.3	63	64	780	790	3784	3984	0.34	0.36
N_{100}	19.5	19.5	8.3	8.4	64	64	800	820	3356	3898	0.35	0.34
N_{150}	20.1	21.0	8.4	8.5	64	65	810	840	3548	3780	0.37	0.37
N_{200}	20.4	22.3	8.5	8.7	65	66	820	850	3590	3790	0.38	0.39
Mean	19.4	20.1	8.2	8.4	63	65	810	820	3445	3833	0.37	0.36

Maize

N rates to Maize	Cob length cm		Cobdiameter cm		Grain no /cob		Grain wt/cob		Test wt		Yield kg/ha		Stover yield kg/ha		Biological yield	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
N_0	9.2	9.5	2.90	2.90	260.0	270.0	48.0	48.2	178.1	179.1	1542	1540	3685	3682	4240	4250
N_{50}	9.5	9.7	3.00	3.10	268.0	278.0	49.8	49.9	180.0	180.5	1546	1545	3690	3691	4245	4255
N_{100}	10.1	10.4	3.20	3.40	270.4	280.4	50.1	50.4	183.2	184.2	1550	1551	3700	3704	4250	4260
N_{150}	10.4	10.5	3.40	3.50	279.1	289.1	52.0	52.2	184.4	185.4	1558	1559	3720	3724	4280	4290
N_{200}	10.5	10.6	3.45	3.65	280.0	290.0	52.8	52.9	185.0	186.0	1560	1562	3744	3748	4289	4299
Mean	10.1	10.3	3.25	3.35	276.2	286.0	50.8	51.4	181.5	182.5	1551	1554	3714	3720	4265	4275

Observation on maize crop

Plant height

In general, there was rapid increase in plant height up to 30 days after sowing (3.82 cm/day during 2010 and 3.94 cm/day during 2011) followed by a phase of slow increase between 30 to 60 DAS (1.38cm/day during 2010 and 1.37 cm/day during 2011) and later stationary phase was noticed during both the years. During the period of rapid increase in plant height, maximum rate of increase was recorded under greengram-maize sequence followed by cowpea-maize sequence during 2010 where as during 2011 greengram-maize sequence was followed by cowpea –maize sequence and black gram-maize sequence while the maximum increase in height due to nitrogen was recorded at 200 kg N/ha during both the years. During both the years, plant height varied significantly due to preceding crops at all the stages (Table 2) At 30 DAS, maximum plant height (140.8 cm) in 2010 and (144.0 cm) in 2011 was recorded under green gram-maize sequence which was significantly more than the height recorded under all other sequence during both the years. Plant height varied significantly due to preceding crops at all the stages.

In 2010 plant height recorded under cowpea -maize sequence was significantly higher than under blackgram-maize, fallow-maize, maize-maize. Plant height recorded under clusterbean-maize was also significantly higher than under fallow-maize and maize-maize sequences. During 2011 plant height recorded under cowpea –maize sequences was significantly higher than plant height noted under cluster bean-maize, fallow-maize and maize-maize. The crop sequence blackgram-maize resulted significantly more plant height as compared to fallow-maize and maize-maize. Rest of the differences in plant height due to different crop sequences were non-significant. At 60 DAS, maximum (167.4 cm) and significantly more plant height was recorded under green gram- maize sequence than all their sequence except cow pea – maize and fallow-maize during 2010. Plant height recorded under cowpea-maize and fallow-maize was also significantly more than under clusterbean-maize. But during 2011 the plant height recorded under greengram- maize sequence was maximum (171.0 cm) and significantly more than plant height recorded under cluster bean- maize, fallow -maize and maize –maize. Plant height recorded under cowpea-maize and blackgram-maize sequences was significantly more than under maize-maize sequence. Rests of the differences were statistically at par.

At 90 DAS, maximum plant height (170.7 cm) was recorded under greengram maize sequence which was significantly more than the plant height recorded under all the sequences except cowpea- maize during 2010. Plant height recorded under cowpea-maize, fallow-maize and maize-maize was significantly higher than under clusterbean-maize. During 2011, maximum plant height (173.9 cm) was also recorded under greengram – maize sequence. But it was significantly more than all other sequences. Further plant height recorded under cowpea-maize, blackgram-maize and clusterbean-maize sequences was significantly more than under maize-maize. Rests of the differences were non-significant. An effect of nitrogen rate on plant height was significantly during both the years. (Table 2) At 30 and 60 DAS during both the years, maximum plant height was recorded with 200 kg N/ha which was significantly more than plant height recorded with 50kg N/ha and no nitrogen treatments. Plant height recorded at 100kg N/ha was significantly more than at 50 kg N/ha but 50 and 100 kg N/ha it was significantly higher than no nitrogen treatment. At 90 DAS plants height recorded with 200 kg N/ha was significantly higher than plant height recorded with 50kg N/ha and no nitrogen during 2010. Plant height recorded at 100 kg N/ha was significantly more than at 50 kg N/ha but 50 and 100 kg N/ha it was significantly higher than no nitrogen treatment. However during 2011 plant height recorded at 200 kg N/ha was significantly higher than no nitrogen treatments only.

Dry matter accumulation

Progressive increase in dry matter accumulation was noted with the advancement of the crop age and maximum dry matter was recorded at 90 days after sowing. Rate of dry matter production was slower (1.31 g/day in 2010 and 1.33 g/day in 2011) up to 60 DAS followed by a rapid increase 2.73 g/day during both the years between 60 to 90 DAS. During the phase of rapid accumulation of dry matter, the maximum rate was 2.94 g/day dry matter during both the years under greengram – maize sequences. Rate of dry matter accumulation increased with increasing nitrogen rate. Maximum rate of dry matter accumulation was noticed with 200 kg N/ha during both the years. Dry matter accumulation was affected significantly due to crop sequences at all the stages of the growth during both the years (Table 3) At 30 DAS, maximum dry matter was noticed under green gram -maize sequences (42.5 g/plant) in 2010 and 45.0 g/pant in 2011 which was significantly more than under all the other crop sequences during both the years.

Table 2. Effect of crop sequences and nitrogen rates on plant height (cm) of maize at various growth stages

Treatment Crop sequences	Days after sowing					
	2010			2011		
	30	60	90	30	60	90
maize – maize	98.0	156.6	159.0	102.7	147.8	152.0
fallow –maize	101.3	158.7	160.9	104.3	156.0	157.6
Greengram – maize	140.8	167.4	170.7	144.0	171.0	173.9
Cowpea- maize	124.0	159.7	161.7	127.7	161.5	165.2
Blackgram- maize	105.5	153.0	153.3	121.7	160.2	164.0
Clusterbean –maize	118.4	141.7	148.3	108.7	159.2	163.3
S.Em+_	5.0	2.7	3.0	5.0	3.5	2.7
C.D at 5 %	15.9	8.7	9.4	16.0	11.3	8.5
Nitrogen rates (kg/ha)						
0	102.2	132.8	137.0	103.6	136.7	140.7
50	111.8	156.4	161.9	114.3	162.0	165.8
100	121.0	167.2	169.0	124.9	168.0	171.4
150	126.4	168.3	168.1	130.0	170.5	172.1
200	127.3	169.4	169.2	131.3	171.8	173.1
S.Em+_	2.1	1.4	2.3	2.4	1.7	2.4
C.D. at 5 %	6.30	4.0	6.7	6.9	4.9	7.1

During 2011 dry matter under cowpea- maize was significantly more than fallow- maize and maize – maize sequence.

At 60 DAS also , maximum dry matter (86.5 g/ plant in 2010 and 87. 3 g/ plant in 2011 was recorded under greengram - maize sequences which was significantly more than under all the other crop sequences during both the years. During 2011 dry matter under cowpea – maize sequence was also significantly higher than under maize – maize. At 90 DAS also maximum dry matter (174 .7 g/plant in 2010 and 176.0 g/plant in 2011) was recorded under greengram maize sequence which was significantly higher than under all the other crop sequences in both the year. Further during 2010 dry matter cowpea-maize sequence was significantly more than under maize-maize, fallow-maize, blackgram-maize and clusterbean-maize sequences. Similarly, dry matter under blackgram-maize and clusterbean-maize sequences. Later dry matter recorded under blackgram-maize and fallow-maize. During 2011, dry matter under cowpea-maize was significantly more than under blackgram-maize, clusterbean-maize, maize-maize and fallow-maize. Further dry matter under blackgram-maize and maize-maize was significantly higher than under clusterbean-maize and fallow-maize sequences. Rate of nitrogen application significantly affected the dry matter production at all the growth stages during both the years. (Table 3) At all the stages during both the years dry matter recorded with 150 kg N/ha and 200 kg N/ha being statistically at par was significantly higher than dry matter obtained under other rates including control. Successive increase in nitrogen rate increased the dry matter accumulation significantly at all the stages during both the years.

Table 3. Effects of crop sequence and nitrogen rates under dry matter accumulation (g/plant) by maize at various growth stages

Treatment Crop sequences	Days after sowing					
	2010			2011		
	30	60	90	30	60	90
maize – maize	38.9	75.2	160.5	39.4	76.1	153.6
fallow –maize	37.5	75.9	156.1	39.9	77.8	157.4
Greengram – maize	42.5	86.5	174.7	45.0	87.8	176.0
Cowpea- maize	39.2	79.2	164.8	42.2	80.4	165.8
Blackgram- maize	38.8	78.4	156.9	41.1	79.8	161.7
Clusterbean –maize	37.5	77.2	152.5	41.0	78.3	157.9
S.Em±	0.8	1.5	1.1	0.7	1.3	0.9
C.D at 5 %	2.5	4.7	3.1	2.3	4.3	2.9
Nitrogen rates (kg/ha)						
0	24.3	48.7	102.7	26.4	50.1	103.7
50	35.5	74.2	149.6	38.0	75.9	151.0
100	46.1	91.9	186.3	48.5	92.5	187.4
150	50.3	100.2	205.1	52.8	101.6	206.1
200	51.1	101.3	206.0	52.9	102.8	207.2
S.Em±	1.0	1.9	1.4	1.0	2.0	1.4
C.D. at 5 %	2.9	5.6	4.2	3.0	5.8	4.2

Leaf area index

Average leaf area index was maximum at 60 DAS (3.26 in 2010 and 3.32 in 2011) there was rapid increase in leaf area index up to 30 DAS (0.061 / day in 2010 and 0.061 in 2011) followed by slightly lower rate of increase between30 to 60 DAS (0.048 / day in 2010 and 0.049 /day in 2011). At later stage i.e. between 60 to 90 DAS, it decreased rapidly at the rate of (0.065 / day). During the rapid phase, maximum rate of increase in L AI (0.063/ day in 2010 and 0.064/ day in 2011) was noted under greengram – maize sequence. However, the minimum rate was noticed under maize – maize sequence during both the years while in case of nitrogen LAI development was with maximum rate (0.069/day in 2010 and 0.071/day on 2011) at 200 kg N/ha. During both the years, LAI differed significantly due to different crop sequences at all the stages.

Table 4. Effects of crop sequences and nitrogen rates on leaf area index (LAI) of maize at various growth stages

Treatment crop sequences	Days after sowing					
	2010			2011		
	30	60	90	30	60	90
Maize – maize	1.74	3.07	1.15	1.79	3.14	1.20
fallow –maize	1.74	3.14	1.18	1.80	3.20	1.21
Greengram – maize	1.89	3.39	1.42	1.92	3.45	1.45
Cowpea -maize	1.85	3.37	1.40	1.90	3.43	1.43
Blackgram- maize	1.82	3.33	1.34	1.85	3.36	1.37
Clusterbean –maize	1.79	3.31	1.34	1.84	3.37	1.39
S.Em±	0.01	0.04	0.01	0.01	0.03	0.01
C.D at 5 %	0.04	0.13	0.04	0.04	0.12	0.04
Nitrogen rates (kg/ha)						
0	1.53	2.76	1.11	1.57	3.82	1.14
50	1.68	3.19	1.19	1.71	3.24	1.24
100	1.93	3.49	1.45	1.98	3.56	1.50
150	2.08	3.63	1.46	2.14	3.68	1.49
200	2.09	3.86	1.48	2.16	3.72	1.53
S.Em±	0.01	0.03	0.01	0.01	0.03	0.01
C.D. at 5 %	0.05	0.11	0.05	0.05	0.10	0.05

At 30 DAS, maximum as well as significantly higher LAI was noted under green gram – maize sequence over all other sequence except cowpea – maize during both the years. In 2010, leaf area index recorded cowpea-maize sequence was significantly higher than under clusterbean-maize, fallow-maize and maize-maize sequence. However, clustrbean-maize resulted significantly more LAI than fallow-maize and maize-maize. During 2011, Leaf area index recorded under cowpea-maize sequence was significantly higher than under blackgram-maize, clusterbean-maize, fallow-maize and maize-maize sequences. Further LAI noted under blackgram-maize was significantly more than under fallow-maize and maize-maize. Similarly clusterbean–maize sequence was significantly superior to maize-maize. At 60 DAS, greengram – maize, cowpea – maize, blackgram-maize and cluster bean-maize sequences resulted significantly higher leaf area index than fallow -maize and maize- maize sequence during both the years. At 90 DAS, leaf area index recorded under greengram – maize sequence was significantly more than under all the other sequences except cowpea- maize sequences during both the years. Further leaf area index under blackgram-maize and clusterbean-maize sequences was significantly higher than under fallow-maize and maize-maize sequences during both the years. In 2010, LAI under cowpea-maize was significantly higher than under blackgram-maize, clusterbean-maize fallow-maize and maize-maize sequences. But in 2011 cowpea-maize sequence resulted significantly more leaf area index than blackgram-maize, fallow-maize and maize-maize sequences. Nitrogen rates influenced LAI significantly at all the growth stages during both the years (Table 4). At 30 and 60 DAS, each successive increase in nitrogen rate caused in significant increase in LAI during both the years up to 200 kg N/ha, although LAI at 150 kg and 200 kg N/ha being at par. At 90

DAS , LAI with 150 kg nitrogen and 200 kg nitrogen being at par was significantly higher than at 50 kg N / ha and no nitrogen treatment during both the years. LAI recorded at 100 kg N/ha was significantly more than at 50 kg N/ha. But at 50 and 100 kg N/ha it was significantly higher than no nitrogen treatment during both the years.

Days to tasseling & Days to silking

Number of days to tasseling was not affected significantly due to various crop sequences during both the year, (Table 5) However, minimum number of days to attain tasseling stage was observed under greengram – maize cropping sequence while maximum number of days was noted under maize-maize cropping sequence. Rate of nitrogen application caused significantly variation in number of days to tasseling during both the years, (Table 5). Minimum number of days to tasseling was noted with 200kg N/ha and it was significantly lesser than with no nitrogen and 50 kg N/ha during both the years. In 2010, number of days recorded with 100 kg N/ha was significantly lesser than with no nitrogen treatment. But in 2011, number of days to tasseling with 50 and 100 kg N/ha was significantly lesser than no nitrogen treatment only. Number of days to silking varied significantly due to preceding crops during both the year, (Table 5). Minimum number of days to silking was noted under greengram –maize sequences. Number of days to silking under greengram – maize, cowpea-maize, blackgram-maize and clusterben- maize sequences was significantly lesser than under fallow- maize. And maize-maize sequence during both the years. Nitrogen application caused significant variation in number of days to silking during both the years. (Table 5) Minimum number of days to silking was observed with 200 kg N/ha and number of days noted at 100 and 150 kg N/ha. Was significantly lesser than with no nitrogen and 50 kg N/ha. Further the number of days to silking with 50 kg N/ha was significantly lesser than with no nitrogen during both years.

Table 5. Effects of crop sequences and nitrogen rates days taken to tasseling and silking

Treatments crop sequences	Tasseling		Silking	
	2010	2011	2010	2011
Maize-maize	48.1	47.0	57.0	55.8
Fallow- maize	48.0	47.0	57.3	55.8
Greengram -maize	47.0	46.0	54.7	53.3
Cowpea- maize	47.1	46.0	55.2	53.8
Blackgram -maize	47.2	46.0	55.8	54.4
Clusterbean -maize	47.1	47.0	55.7	54.5
S.Em±	0.3	0.4	0.5	0.5
C.D.	NS	NS	1.7	1.7
Nitrogen rates (kg/ha)				
0	48.6	48.0	60.6	59.1
50	47.7	47.0	56.0	54.8
100	47.0	46.1	53.6	52.3
150	46.3	45.2	53.4	52.3
200	46.1	45.0	53.1	52.1
S.Em±	0.3	0.3	0.6	0.7
C.D at 5 %	NS	NS	1.7	1.9

Studies at harvest

Plant stand

Plant stand was not affected significantly due to various preceding crops and nitrogen rates during both the years. (Table 6)

Table 6. Effect of crop sequences and nitrogen rates on plant stand of maize at harvest

Treatments crop sequences	Plant stand (000/ha)	
	2010	2011
Maize – maize	70.9	71.6
Fallow -maize	69.6	70.8
Greengram -maize	70.3	71.0
Cowpea- maize	69.9	70.8
Blackgram -maize	69.3	70.0
Clusterbean -maize	70.2	70.9
S.Em.±	0.4	0.3
C.D at 5 %	NS	NS
Nitrogen rates (kg/ha)		
0	69.6	70.4
50	70.3	71.2
100	70.1	70.8
150	70.1	71.0
200	71.3	71.4
S.Em±	0.4	0.4
C.D. at 5 %	NS	NS

Barrenness percentage

Percent barren plants did not differ significantly due to various crop sequences during both the years. (Table 7) blackgram-maize sequence had minimum percent of barren plants(11.67 in 2010 and 11.52 in 2011). While it was maximum under maize-maize sequence (17.03 in 2010 and 15.98 in 2011). Nitrogen application resulted significantly variation in percent barren plants during both the years. (Table 7). Percentage of barren plants noted with 200kg N/ha was minimum and significantly lesser than with all others level of nitrogen including control. Similarly, percentage of barren plants at 50 and 100 kg N/ha was also significantly lesser than under no nitrogen treatment.

Table 7. Effect of crop sequences and nitrogen rates on percent barren plants of maize at harvest

Treatments crop sequences	Barren plants (000/ha)	
	2010	2011
Maize – maize	17.0	16.0
Fallow -maize	14.2	13.6
Greengram -maize	14.4	14.1
Cowpea- maize	13.7	13.5
Blackgram -maize	11.7	11.5
Clusterbean -maize	13.0	13.1
S.Em. ±	1.1	0.9
C.D at 5 %	NS	NS
Nitrogen rates (kg/ha)		
0	24.3	23.9
50	13.7	13.3
100	11.2	11.1
150	6.8	8.3
200	5.6	6.2
S.Em±	1.0	1.0
C.D. at 5 %	NS	NS

Cob number

Number of cobs per hector did not differ significantly due to various crop sequences during both the years (Table 8). Rate of nitrogen application caused significant variations in cob number during both the years. (Table 8) Maximum number of cob was recorded with 150 and 200 kg N/ha which was significantly higher than all other nitrogen rates. Further the number of cob recorded with 50 and 100 kg N/ha was also significantly higher than the control during both the years.

Table 8. Effect of crop sequences and nitrogen rates on cob number of maize

Treatments crop sequences	Cob number (000/ha)	
	2010	2011
Maize – maize	58.8	60.1
Fallow -maize	59.7	61.2
Greengram -maize	60.1	61.2
Cowpea- maize	60.3	61.1
Blackgram -maize	61.2	61.9
Clusterbean -maize	61.0	61.1
S.Em.±	0.6	0.6
C.D at 5 %	NS	NS
Nitrogen rates (kg/ha)		
0	52.6	53.5
50	60.5	61.5
100	62.2	62.9
150	65.3	66.8
200	66.2	67.2
S.Em±	0.6	0.6
C.D. at 5 %	1.7	1.7

Summary and Conclusion

Maximum number of cobs (61,200/ha in 2010 and 61,900/ ha in 2011) was recorded under blackgram –maize sequence which was comparable to number of cobs/ha under greengram-maize while it was minimum under maize-maize sequence during both the years. Number of cobs was maximum 66,200/ha in 2010 and 67,200/ha 2011 with 200kg/ha and it was minimum under no nitrogen application. Percentage of barren plants was minimum (11.7 in 2010 and 11.5 in 2011) under blackgram-maize sequence which was comparable to greengram –maize sequence, while maximum percentage of barren plants was recorded under maize-maize sequence. Minimum percentage of barren plants (5.6 in 2010 and 6.2 in 2011) was recorded with 200kgN/ha and it was maximum under no nitrogen application. Minimum number of days to silking (54 .7 in 2010 and 53.3 in 2011) was recorded under greengram– maize sequence while it was maximum (57.3 in 2010 and 55 .8 in 2011) under maize– maize sequences. Number of days to silking was minimum (53.1 in 2010 and 52 .1 in 2011) with 200 kg N/ha while it was maximum (60 .6 in 2010 and 59 .1 in 2011) under no nitrogen application. At maturity (90 days after sowing), maximum dry matter accumulation per plant (174.7 g in 2010 and 176.0 g in 2011) was recorded under greengram– maize sequences and it was minimum under maize– maize sequences. It was maximum (206.0 g in 2010 and 207.2 g in 2011) with 200kg N/ha minimum with no nitrogen. At maturity (90 DAS) maximum plant height (170.7 cm in 2010 and 173.9 cm in 2011) under greengram– maize sequences while it was minimum under maize– maize. At maturity (90 DAS) maximum plant height (169.2 cm in 2010 and 173.1 cm 2011) was recorded with 200 kg N/ha while it was minimum with no nitrogen application. At silking stages (60 DAS) maximum leaf area index (3.39 in 2010 and 3.45 in 2011) was recorded under greengram – maize sequences and it was minimum under maize – maize . At silking stage (60 DAS) leaf area index was maximum (3.86 in 2010 and 3.72 in 2011) with 200 kg N/ha while it was minimum with no nitrogen application.

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