RESEARCH ARTICLE Indian Journal of Agricultural Research, Volume 58 Issue 2: 266-272 (April 2024)

Effect of Legume Crop Residues and Nitrogen Management on Growth Parameters and Growth Indices of Maize (*Zea mays* L.)

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10.18805/IJARe.A-5679

ABSTRACT

Background: Maize (*Zea mays* L.) is one of the important cereal crop and its demand is increasing due to its versatile use but the productivity in India is still low. The basic requirement for improving the crop productivity is soil fertility and it is highly related with soil organic matter. Due to unavailability of organic manure and their higher cost, cheaper the organic source available at farm should be explored to meet the requirement.

Methods: A field experiment was conducted at College Agronomy Farm, B.A. College of Agriculture, AAU, Anand during summer-*kharif* seasons of years 2017 and 2018 to examine the impact of legume crop residue and nitrogen levels on maize crop. Experiment comprised of three legume crops grown in summer season *viz.,* green gram, groundnut and cluster bean, two residue management treatments *viz.,* residue removal and incorporation and three nitrogen levels in *kharif* maize *viz.,* 100%, 75% and 50% recommended dose of nitrogen.

Result: Results indicated that cluster bean-maize sequence provided the highest leaf area and leaf area index at 60 days after sowing, chlorophyll content and dry matter production at 30 and 60 days after sowing and crop growth rate for of maize crop. Incorporation of legume residues also had significant effect on plant height, dry matter production and chlorophyll content; leaf area and leaf area index at 60 days after sowing and crop growth rate and absolute growth rate of maize crop. Application of 100% RDN beneficially affected all the growth parameter and indices. Overall, summer legume cropping with their residue incorporation and higher nitrogen levels favourably impacts on various growth parameters and growth indices of maize crop.

Key words: Cropping system, Legume, Maize, Nitrogen, Residue management.

INTRODUCTION

Maize (*Zea mays* L.) is one of the important cereal crop considered as “Queen of cereals” next only to wheat and rice in the world. Globally, maize is cultivated in an area of 179 m ha with the production of 967 m tonnes having 5402 kg ha^{-1} average productivity (Anonymous, 2017a). In India, it is cultivated in 9.86 m ha with the production of 26.26 m tonnes and 2663 kg ha^{-1} productivity (Anonymous, 2017b), however in Gujarat, it is cultivated on 0.40 m ha area with production of 0.72 m tonnes and productivity 1800 kg ha^{-1} (Anonymous, 2017c). As the demand for the maize is increasing globally due to its multiple uses, there is a need to enhance its productivity from the same or alternate available resources.

Various studies state that the basic requirement for improving the crop productivity lies in the betterment of soil fertility. The fertility of soil is highly related with soil organic matter. Intensive cropping and tillage system resulted in substantial decrease in soil organic matter levels. Rotating cereals and legumes is a cheaper means of improving soil fertility and system productivity. Legumes are well known to add significant amount of organic carbon and atmospheric N fixed in to the soil. Therefore, there is need to assess legume crops in crop sequences as an alternate source for N supply in crop sequences.

Increasing costs of N fertilizers and growing consciousness towards safer environment have led towards use of organic sources of nutrients. Nonetheless, organic manures need to be applied in bulk to meet the heavy nutrient requirement of crops. Cheaper organic source which is abundantly available should be explored to satisfy the nutrient requirement of high yielding crops. The use of organic inputs such as leguminous crop residues could be an alternative for maintaining soil fertility and sustain crop yields (Zoumane *et al.,* 2000). Crop residues not only supplies all the major and micro nutrients, but also acts as a soil conditioner, improves the physical, chemical and biological properties (Mandal *et al*., 2004).

In searching for alternative of mono-cropping, diversification of cropping systems incorporating short

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How to cite this article: Shukla, M., Sadhu, A.C., Mevada, K.D., Shitap, M. and Patel, P. (2024). Effect of Legume Crop Residues and Nitrogen Management on Growth Parameters and Growth Indices of Maize (*Zea mays* L.). Indian Journal of Agricultural Research. 58(2): 266-272. doi: 10.18805/IJARe.A-5679.

Submitted: 08-09-2020 **Accepted:** 04-03-2021 **Online:** 07-04-2021

duration legume crops in the cropping sequence should be done. After the harvest of the economic part, legume crop residues can be incorporated to the soil which will serve good source of plant nutrients and readily available energy for soil microbes because of their relatively high nutrient content, low lignin content and easy decomposition. The contribution of legume residues on productivity of the succeeding maize and their nitrogen economy was not thoroughly investigated. Hence, the present study was carried out with the objective to study the effect of different legume crop residue management with different nitrogen levels on the growth and growth indices of maize crop.

MATERIALS AND METHODS

A field experiment was conducted at College Agronomy Farm, B.A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India during summer-*kharif* seasons of years 2017 and 2018. Anand is situated at 22° 35′N latitude, 72°55′E longitude with an elevation of 45.1 m above the mean sea level.Climate of this region is semi-arid and sub-tropical with an average annual rainfall of 864.5 mm, which is realized entirely from the South-West monsoon currents. The experimental field had an even topography with a gentle slope having good drainage and loamy sand in texture. The soil of the experimental field at 0-15 cm depth was low in organic carbon (0.34%) and available N (141.1 kg ha^{-1}), medium in available P_2O_5 (36.2 kg ha^{-1}) and K_2O (226.8 kg ha^{-1}) and slightly alkaline in reaction (pH-8.24, EC-0.18).

Experiment details

The experiment was laid in strip-split plot design with four replications. Three legume crops *viz.*, green gram (C_1), groundnut (C_2) and cluster bean (C_3) was grown in summer season and designated as vertical strips. Each legume crop strip had been sub-divided into two horizontal strips, for residue management treatments *viz.,* residue removal (R_0) and residue incorporation (R_1); which further split into three intersectional sub plots designated with three nitrogen levels in succeeding *kharif* maize *viz.,* 100% RDN (N_1), 75% RDN (N_2) and 50% RDN (N_3). Green gram *var.* GAM 5, groundnut *var.* GJG 31 and cluster bean *var.* GG 2 were grown in summer season of both the years. All legumes in summer season received equal amounts of nutrients *i.e.*, 20 kg N and 40 kg P_2O_5 per ha as basal dose. Sowing of legumes were done in summer season on 22nd February in 2017 and 14th February in 2018 with row spacing of 30 cm. Harvesting of green gram was done in first fortnight of May and cluster bean and groundnut were harvested in first week of June. Maize *var.* GAWMH 2 was sown as main *kharif* crop with spacing of 60 cm and all the treatments were conferred upon it during both the years. The recommended dose of fertilizer for maize crop was 150:65:00 NPK, kg ha^{-1} which given as per treatment and full P dose and 1/3rd of N dose as basal and two N (1/3rd dose at each time) top dressing. Source of application of nutrient was urea and DAP during both seasons.

Residue management

Residue yield was obtained by subtracting the grain yield of legumes of each net plot from their respective total dry biomass (above ground) and computed in terms of kg per net plot and then on hectare basis. The weight of pod residue after threshing (pods) was also recorded and converted on hectare basis. Nutrient (N, P and K) content of residue of legumes were estimated by as per the procedures described in Jackson (1973). After incorporation of residue in soil one irrigation was given for proper decomposition. The biomass was allowed to decompose for about 20 days in the field.

Data recording

Five plants were selected and tagged at random from each net plot to record observations on various growth characters at different stages of maize. Leaf area per plant (cm^2) at 30 and 60 days after sowing was measured with automatic leaf area meter instrument by cutting all the green leaves from three plants of the net plot. Chlorophyll content SPAD value (Soil Plant Analysis Development) at 30 and 60 days after sowing was measured with the instrument CCM-200 plus chlorophyll content meter. For dry matter production, same plants used for leaf area were dried in the sun for 48 hours followed by air drying in shade till a constant weight was obtained. Dry weight per plant was calculated then further converted in kg ha^{-1} basis. With the help of different growth parameters different growth indices were calculated with following formula's:

Leaf area index (Williams, 1946).

$$LAI = \frac{\text{Leaf area } (m^2)}{\text{Ground area } (m^2)}$$

Absolute growth rate (AGR) (cm day^{-1}) (Rana and Kumar, 2014).

$$AGR = \frac{H_2 - H_1}{t_2 - t_1}$$

Where:

H_1 and H_2 = Plant height of plant at 30 and 60 DAS.

t_1 and t_2 = Time of plant height of plant *i.e.* 30 and 60 DAS.

Crop growth rate (CGR) (g per m^2 day^{-1}) (Watson, 1952).

$$CGR = \frac{W_2 - W_1}{A\,(t_2 - t_1)}$$

Where:

W_1 and W_2 = Dry weight of plant at 30 and 60 DAS.

t_1 and t_2 = Time of dry weight of plant *i.e.* 30 and 60 DAS.

A = Land area.

Net assimilation rate (NAR) (g per cm^2 day^{-1}) (Williams, 1946).

$$NAR = \frac{(W_2 - W_1)\ (\log L_2 - \log L_1)}{(t_2 - t_1)(L_2 - L_1)}$$

Where:

W_1 and W_2 = Dry weight of plant at 30 and 60 DAS.

t_1 and t_2 = Time of dry weight of plant *i.e.* 30 and 60 DAS.

L_1 and L_2= leaf area of plant at 30 and 60 DAS.

Log = Natural logarithm.

Statistical analysis

The statistical analysis of the data of the *kharif* maize were performed in Strip-Split Plot Design by computer system at the Computer Center, Department of Agricultural Statistics, BACA, AAU, Anand as per the procedure described by Cochran and Cox (1957). Cropping systems, residue management and nitrogen management data were subjected to an ANOVA and means were compared using t-test, with α = 0.05 level.

RESULTS AND DISCUSSION

Among the three summer legumes, cluster bean produced the highest amount of total residue (haulm + pod residue) followed by groundnut (Table 1). It might be due to short growing period of green gram as compared to groundnut and cluster bean. The nutrient content of cluster bean residue was also found higher which resulted in highest amount of nutrient addition to the soil (76.34 kg ha^{-1} N, 19.42 kg ha^{-1} P and 42.01 kg ha^{-1} K) followed by groundnut crop when residue was incorporated (Table 1).

Effect on maize

A) Cropping systems

Two year study revealed that plant population of maize at 20 DAS and at harvest and plant height of maize at 30 DAS, 60 DAS and at harvest was not affected due to different cropping systems (Table 2). Leaf area at initial stage (30 DAS) was not affected due to cropping systems however at 60 DAS higher leaf area (3505 cm^2) was observed with cluster bean-maize cropping sequence. Cluster bean-maize cropping sequence reported higher chlorophyll content at 30 and 60 DAS (20.94 and 24.18, respectively) and dry matter production at 30 and 60 DAS and at harvest (768.7, 5659 and 14187 kg ha^{-1}, respectively). Groundnut-maize (C_2) cropping sequence gave comparable results with cluster bean-maize (C_3) for leaf area at 60 DAS, chlorophyll content at both intervals and dry matter production at 30 DAS (Table 2). The results might be due to increased nitrogen and other nutrient availability in the soil for growing maize crop due to previous legume crops. The difference in growth of maize observed between preceding legumes might be due to their different carry over capacity of nitrogen for the succeeding maize crop. In present study cluster bean produced the highest amount of crop residue followed by groundnut, so their high amount of leaf litter, root residue and nitrogen addition to the soil can be correlated with the similar results of these systems. Adeleke and Haruna (2012), Rekha (2014) and Ali *et al.* (2015) also reported similar effect of different preceding legume crops on growth parameters of succeeding maize.

Different cropping systems did not exercise any significant influence on initial growth indices *viz*. leaf area index at 30 DAS, absolute growth rate for 0-30 and 30-60 DAS and net assimilation rate for 30-60 DAS of maize crop (Table 3). However higher leaf area index at 60 DAS (2.92) and crop growth rate of maize crop for 0-30 and 30-60 DAS (2.60 and 16.57 g per m^2 day^{-1}, respectively) was noted with cluster bean-maize sequence which was statistically at par with groundnut-maize cropping sequence (Table 3). Significant effect of above two cropping systems on various growth attributes leads to the better results of calculated growth indices of maize.

B) Residue management

Residue management of summer crops did not affect plant population of maize at 20 DAS and at harvest. Incorporation of legume residues (R_1) significantly improved plant height of maize at 30 and 60 DAS and at harvest (48.3, 173.7 and 177.8 cm, respectively) (Table 2). The findings are in corroboration with the reports of Ammaji (2014) and Ndiso *et al.* (2018). Initially at 30 DAS, leaf area of maize was unaffected but incorporation of residues gave significant results for leaf area at 60 DAS (3498 cm^2), chlorophyll content at 30 and 60 DAS (20.10 and 24.20, respectively) and dry matter production of maize at 30 and 60 DAS and at harvest (763, 5469 and 13939 kg ha^{-1}, respectively) (Table 2). Ali *et al.* (2015) and Ndiso *et al.* (2018) also observed similar results and it might be due to improved mineralization and of high amount of accumulated nitrogen in the legume residue which was returned to the soil. Addition of organic matter in form of crop residues boosted availability of nitrogen and other nutrients which might have resulted in better crop growth of maize.

Table 1: Yield and nutrient content of summer legume residue and nutrient addition (kg ha^{-1}) in the soil through crop residues incorporation. (Average data of two years).

Crop		Residue yield (kg ha^{-1})	Nutrient content (%)			Addition of nutrients (kg ha^{-1})		
			N	P_2O_5	K_2O	N	P_2O_5	K_2O
Green gram	Haulm	2424	1.71	0.16	0.78	41.40	8.88	22.76
	Pod residue	234	1.88	0.17	0.44	4.41	0.89	1.24
	Total	2658	3.59	0.33	1.22	45.81	9.76	23.99
Groundnut	Haulm	3297	1.74	0.21	0.92	57.24	15.99	36.47
	Pod residue	536	1.51	0.12	0.95	8.11	1.45	6.14
	Total	3833	3.25	0.33	1.87	65.36	17.43	42.61
Cluster bean	Haulm	3619	1.79	0.20	0.84	64.86	16.66	36.48
	Pod residue	803	1.43	0.15	0.57	11.49	2.76	5.53
	Total	4422	3.22	0.35	1.41	76.34	19.42	42.01

Table 2: Plant population and different growth parameters of *kharif* maize as influenced by different treatments (Pool data of two years).

Treatment	Plant population (per m row)		Plant height (cm)			Leaf area (cm^2)		Chlorophyll content (SPAD value)		Dry matter production (kg ha^{-1})		
	20 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS	At harvest
Cropping systems (C)												
C_1: Green gram-Maize	4.73	4.62	46.4	167.8	170.8	673.1	3250	19.95	22.86	719.0	5213	13054
C_2: Groundnut-Maize	4.78	4.69	47.4	169.3	173.2	687.2	3410	20.35	23.85	743.6	5469	13518
C_3: Cluster bean-Maize	4.77	4.67	48.4	171.4	176.2	701.2	3505	20.94	24.18	768.7	5659	14187
SEm±	0.05	0.05	0.6	2.1	2.0	10.5	52	0.24	0.28	11.1	64	152
CD at 5%	NS	NS	NS	NS	NS	NS	160	0.75	0.86	34.1	198	468
CV %	7.80	7.92	9.28	8.63	8.21	10.58	10.62	8.27	8.14	10.32	8.18	7.74
Residue management (R)												
R_0: Residue removal	4.76	4.66	46.5	165.3	169.0	679.5	3279	19.82	23.06	724.5	5306	13234
R_1 : Residue incorporation	4.76	4.66	48.3	173.7	177.8	694.8	3498	20.10	24.20	762.9	5588	13939
SEm±	0.03	0.03	0.4	1.3	1.3	7.5	34	0.18	0.17	8.1	43	107
CD at 5%	NS	NS	1.5	4.4	4.5	NS	118	0.63	0.60	28.1	149	370
CV %	5.45	5.39	7.74	6.44	6.31	9.31	8.51	7.54	6.21	9.26	6.71	6.67
Nitrogen management in Maize (N)												
N_1: 100% RDN	4.80	4.69	51.9	177.7	181.6	722.4	3556	22.90	25.22	950.0	6064	14537
N_2: 75% RDN	4.75	4.66	49.3	170.6	174.2	692.5	3402	20.36	23.80	745.3	5413	13438
N_3: 50% RDN	4.72	4.63	41.0	160.2	164.4	646.6	3207	17.98	21.88	536.0	4864	12784
SEm±	0.05	0.05	0.9	1.0	1.0	10.4	25	0.16	0.14	32.4	25	40
CD at 5%	NS	NS	5.5	3.0	2.8	63.2	70	0.45	0.40	197.1	71	112
CV %	5.31	5.27	6.61	5.75	5.37	6.59	6.92	5.48	5.45	6.91	5.72	5.39

Table 3: Growth indices of *kharif* maize as influenced by different treatments (Pooled data of two years).

Treatment	Leaf area index		Absolute growth rate (cm day^{-1})		Crop growth rate (g per m^2 day^{-1})		Net assimilation rate (g per cm^2 day^{-1}× 0.001)
	30 DAS	60 DAS	0-30 DAS	30-60 DAS	0-30 DAS	30-60 DAS	30-60 DAS
Cropping systems (C)							
C_1: Green gram - Maize	0.561	2.71	1.55	4.05	2.43	15.22	1.12
C_2: Groundnut - Maize	0.573	2.84	1.58	4.06	2.52	16.01	1.14
C_3: Cluster bean - Maize	0.584	2.92	1.61	4.10	2.60	16.57	1.15
SEm±	0.009	0.04	0.02	0.07	0.04	0.21	0.02
CD at 5 %	NS	0.13	NS	NS	0.12	0.66	NS
CV %	10.58	10.62	9.28	11.83	10.31	9.31	11.62
Residue management (R)							
R_0: Residue removal	0.566	2.73	1.55	3.96	2.45	15.52	1.13
R_1 : Residue incorporation	0.579	2.91	1.61	4.18	2.58	16.35	1.14
SEm±	0.006	0.03	0.01	0.05	0.03	0.13	0.01
CD at 5 %	NS	0.10	0.05	0.17	0.10	0.43	NS
CV %	9.31	8.51	7.72	10.54	9.27	6.66	9.34
Nitrogen management in Maize (N)							
N_1: 100% RDN	0.602	2.96	1.73	4.19	3.22	17.33	1.18
N_2: 75% RDN	0.577	2.83	1.64	4.04	2.52	15.81	1.12
N_3: 50% RDN	0.539	2.67	1.37	3.97	1.81	14.66	1.11
SEm±	0.009	0.02	0.03	0.04	0.11	0.09	0.01
CD at 5 %	0.053	0.06	0.18	0.11	0.67	0.25	0.02
CV %	6.59	6.92	6.61	6.67	6.90	6.63	7.63

Net assimilation rate of maize crop for 30-60 DAS and leaf area index at 30 DAS was not influenced by residue management, however, incorporation positively increased leaf area index at 60 DAS (2.91), absolute growth rate for 0-30 and 30-60 DAS (1.61 and 4.18 cm day^{-1}, respectively) and crop growth rate for 0-30 and 30-60 DAS (2.58 and 16.35 g per m^2 day^{-1}, respectively) of maize crop. A positive effect on various growth attributes due to residue incorporation, could lead to better results for growth indices of maize. Similar results were also reported by Cheruiyot *et al.* (2001).

C) Nitrogen management in maize

Results indicated that nitrogen management in maize showed non-significant effect on plant population of maize at 20 DAS and at harvest. Full dose of nitrogen in maize significantly increased plant height at 30 and 60 DAS and at harvest (51.9, 177.7 and 181.6 cm, respectively), leaf area at 30 and 60 DAS (722.4 and 3556 cm^2, respectively), chlorophyll content at 30 and 60 DAS (22.90 and 25.22, respectively) and dry matter production at 30 and 60 DAS and at harvest (950.0, 6065 and 14537 kg ha^{-1}, respectively) (Table 2). Improved growth parameters with full dose of N might be due to role of nitrogen in increasing cell division, cell elongation and chlorophyll formation. Similar findings reported by Rekha (2014) and Singh *et al.* (2015).

Various growth indices of maize crop were positively affected with increasing nitrogen dose in maize. Highest values for leaf area index at 30 and 60 DAS (0.602 and 2.96, respectively), absolute growth rate 0-30 and 30-60 DAS (1.73 and 4.19 cm day^{-1}, respectively), crop growth rate for 0-30 and 30-60 DAS (3.22 and 17.33 g per m^2 day^{-1}, respectively) and net assimilation rate for 30-60 DAS (1.18 g cm^{-2} day^{-1} × 0.001) of maize was observed with application of 100% recommended dose of nitrogen. Best results with full dose were obviously due to adequate supply of nitrogen which could help the maize to increase its growth, which in turn resulted in better growth indices. Similar finding was observed by Imran *et al.* (2015) and Meena *et al.* (2016).

CONCLUSION

On the basis of results of two years of experimentation with cropping system, residue and nitrogen management, it can be concluded that cluster bean-maize cropping system significantly affected the various growth parameters *i.e.* leaf area, chlorophyll content and dry matter production and among growth indices, leaf area index at 60 DAS and crop growth rate of maize crop. Residue incorporation of summer legumes proved beneficial in enhancing all the growth parameters and growth indices except initial leaf area and leaf area index and net assimilation rate that indicated its potential to use as an organic manure. Results indicated that full dose of nitrogen in maize was found significant for increasing all the growth parameters and growth indices. Interaction effects of different factors regarding the growth parameters was not found significant that indicate that though preceding legumes and their residue incorporation had positive effects on maize growth, they was not able to reduce the nitrogen requirement through chemical means. Effect of organic manures applied for a short term cannot be assessed as it takes long time to build up organic matter content in the soil and meet the nutrient requirement of crops in a sequence. So long term experimentation is needed to examine the potential of these treatments with respect to reducing nitrogen fertilizer requirement.

ACKNOWLEDGEMENT

We acknowledge the support from Anand Agricultural University, Anand, Gujarat and Indian Council of Agricultural Research (ICAR)-Central Soil Salinity Research Institute, Karnal during the period of experimentations.

Conflict of interest

All authors declare that they have no conflict of interest.

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