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Assessing of Residual Legume Effect on Growth and Yield Parameters of *rabi* Maize under Irrigated Conditions

A. Sai Kishore [a++*], D. Sreelatha [b#], M. Malla Reddy [c†], M. V. Nagesh Kumar [d‡] and T. Sukruth Kumar [e^]

[a] Professor Jayashankar Telangana State Agricultural University, Hyderabad, Telangana, India.
[b] Regional Agriculture Research Station, Polasa, Jagitial-505327, India.
[c] Regional Agricultural Research Station (STZ), Palem, Nagarkurnool-509209, India.
[d] Maize Research Centre, ARI, Rajendranagar, Hyderabad-500030, India.
[e] AICRP on Micro Nutrients, ARI, Rajendranagar, Hyderabad-500030, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted to study the residual influence of preceding legumes and nitrogen levels on growth and yield parameters of *rabi* maize at Maize Research Centre, AgriculturalResearch Institute, Rajendranagar, Hyderabad, during *kharif* and *rabi* of 2021 and 2022. The experiment was laid out in split-plot design with 18 treatments consisted of C1N1: groundnut100% RDN- maize, C1N2: groundnut75% RDN- maize, C2N1: soybean100% RDN-

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++ Ph.D. (Agriculture);
 # Principal Scientist (Agronomy);
† Chairman, Associate Director of Research;
‡ Principal Scientist and Head (Genetics and Plant breeding);
^ Principal Scientist (SSAC);
**Corresponding author: E-mail: saikishore361@gmail.com;*

maize, C2N2: soybean75% RDN- maize, C3N1: greengram100% : greengram100% RDN- maize, C3N2: greengram75% RDN- maize as main-plots and 3 subplots viz.100% RDN, 125% RDN, 150% RDN (kharif and rabi respectively) during twoyears of study. Among the different cropping systems, the preceding kharif greengram with 100% RDN on rabi zero-till maize showed higher growth interms i.e. plant height, leaf area, leaf chlorophyll content (SPAD reading) at 30 DAS, cob length, cob girth and yield in both years. However, with respect to nitrogen levels, application of 150% RDN to rabi maize showed significantly higher growth and yield followed by 125% RDN and lowest was seen in 100% RDN in rabi respectively. On the other hand, the interaction effect with the preceding legume residues on succeeding rabi maize with addition of varied nitrogen levels was found non-significant in 2021-22 and 2022-23.

Keywords: Residues of legumes; nitrogen levels; Zero-till maize; growth and yield.

1. INTRODUCTION

Intensive maize production requires a lot of fertilizer N, which is expensive and inaccessible to resource poor farmers. More so, production of N fertilizers is high energy consuming and its usein farming is regarded as unsustainable. Therefore, sustainable management systems for intensive maize production is eligible. Often, cropsequence involve legumes since they are capable of fixing nitrogen [1]. It is noted that legumes play a vital role in having beneficial foodsecure systems, and rotations involving legumes diversify crop production systems and improve fertility of soils. Another important aspect of residue management is the quality. Residue quality determines the effect of legumes on productivity of soils either by affecting availability of nutrients or soil organic matter. In that context,greengram, soybean and cluster-bean were known higher residual companion for the succeeding cereal system [2].

Substantially among legumes *i.e.* soybean being known as natural fertilizer capacity of fixing nitrogen property with rhizobium which accounts around 125-150 kg N ha-1 through nodules and by leaves about 30-40 kg N ha-1 for succeeding crops [3]. Further greengram being extensively grown as legume crop in India and capable to grow year-round as a purecrop in sequential cropping systems and thus plays a vital role in furthering sustainable agriculture [4].

Although groundnut is energy-rich leguminous crop by fixing atmospheric nitrogen by the root nodule bacteria. Hence, lower doses of nitrogen would be sufficient to raise a good crop and also application of phosphorus and potassium become more essential for obtaining higher yields) [5].

The effect on nutrient availability occurs through release of nutrients or indirectly through decomposition products. Legume crop residues after mineralization by soil enhance the plant parameters. Hence there is the need to evaluate the growth and yield by the residual retention and nitrogen levels on *rabi* maize in both years.

2. MATERIALS AND METHODS

The present experiment was carried out at Maize Research Centre, Agricultural Research Institute, Rajendranagar, Hyderabad, during *kharif* and *rabi* seasons of 2021 and 2022. The farm is geographically situated at an altitude of 542.3 m above mean sea level at 17°19' N latitude and 78°23' E longitude in the Southern Telangana Agro-Climatic Zone of Telangana State and itfalls under Semi-Arid Tropics (SAT) according to Troll's classification. The weather during the cropperiod was most congenial for betterperformance of legume-maize sequence. The weather parameters did not deviate much from the normal mean values of the location of study. Ideal weather conditions prevailed during the crop season for the legume-maize sequence, with temperatures at a normal range (12.60 to 33.20°C), consistent rainfall of 878.54 mm, and sunshine (0.9 to 10 hours day-1) in both years. The experiment was planned in a split-plot design with 6 main-plots and 3 sub-plots which consisted of C1N1: groundnut100% RDN- maize, C1N2: groundnut75% RDN- maize, C2N1: soybean100% RDN- maize, C2N2: soybean75% RDN- maize, C3N1: greengram100% RDN- maize, C3N2: greengram75% RDN- maize cropping systems and sub-plots: F1: 100% RDN, F2:125% RDN, F3:150% RDN in *rabi* respectively during two years.

Kharif legumes viz. (groundnut, soybean and greengram) were sown on June 25th with row spacing of 30 cm and 10 cm between plants. rabi maize was sown on 25th September after harvest of greengram and 23th October in case of soybean and groundnut as sequence crop

under zero-tillage conditions with mechanical planter in both the years of 2021-22 and 2022-23. However, the spacing followed for rabi maize was 60 cm x 20 cm with recommended doses of phosphorus (80 kg ha^{-1} P2o5) and potash (80 kg ha^{-1} K2o) respectively were appliedat basal, along with varied levels of nitrogen as per the treatments in both years. Need based recommended plant protection and cultural practices like weed control, irrigation were adopted for both legumes and maize during the crop growth period. The recommended dose of nitrogen applied for groundnut, soybean and greengram during kharifwere 20, 60, 20 and 240 kg ha-1 for rabi maize respectively

Plant height was recorded from 5 randomly selected plants at 30 DAS by measuring from the base of the stem (ground level) to the top most node in Maize. Leaf area from five destructively sampled plants was measured at regular intervals using the LI-COR Model LI-3100 leaf area meter with transparent conveyor belt having electronic digital display and expressed in m2. Leaf Chlorophyll content-SPAD reading (Soil Plant Analysis Development) was measuredfrom five tagged plants of the net plot with the instrument CCM-200 plus chlorophyll content meter regular intervals by putting the leaf between the sensors of the instrument. Five cobs were randomly selected from the net plot produce of maize and used for studying length and girth of cob. Length of five cobs was measured in centimeter from the butt end to the tip of the cob. Ordinary string (thread) was used for measuring the girth. The thread was wrapped around the cob and the length of threadwas measured. From the net plot, cobs werepicked, sun dried, threshed and cleaned separately for each treatment. Finally, the yield obtained from net plot was expressed on hectare basis as kg ha-1. Grain yield of five tagged plants assigned for post-harvest observations were also added to the net plot yield.

3. RESULTS AND DISCUSSION

The results indicated that growth parameters at 30 DAS, was influenced by the residual retention of *kharif* legumes on *rabi* maize and even by the nitrogen levels application (Table 1).

3.1 Plant Height (cm)

At 30 DAS, the plant height recorded significantly higher growth with the *kharif* greengram-100% RDN (37.33, 36.00 cm) over other treatments (greengram-75% RDN, soybean-100% RDN, soybean-75% RDN) and lowest was seen in groundnut-75%RDN (25.33, 24.33 cm) on *rabi* maize in both years. Thus, the improved plant height was seen with the greengram residual retention which favored for the improved moisture and nutrient status and enhanced the decomposition and availability at 30 DAS and also improved overall crop phenology. The findings were in tune with Bharathi *et al.* [6]..

From the two years of research data, it was found that higher plant height was recorded with application of 150% RDN (34.67, 33.17 cm) on *rabi* maize than 125% RDN (31.67, 30.83 cm) and lowest was seen in 100% RDN (29.17, 27.83 cm). With the higher level of nitrogen at 150% RDN enhanced the nutrient availability, mobilization under zero-till condition that helped the crop to response to higher cell development and enhanced plant growth. However, the interaction effect of residual retention of legumes and nitrogen levels on *rabi* maize was found to be not significant at 30 DAS in both years

3.2 Leaf Area

Significantly higher leaf area was measured at 30 DAS for greengram with 100% RDN (116.75, 117.08 cm^2) over the corresponding greengram with 75% RDN (110.76, 107.84 cm^2) and soybean 100 (100.50, 97.21 cm^2) and 75% RDN on *rabi* maize but lowest leaf area was seen in groundnut when applied with 75%RDN in *kharif* and succeeding *rabi* with 100% RDN in maize crop sequence in both years. Higher leaf area was registered with green gram residues in all the stages and even inboth years, there might be the availability of the photosynthates due to faster deposition of nutrients for extended growth of leaf morphology over the crop duration. The higher leaf area was conferred with application of 150% RDN in *rabi* maize (102.97, 98.88 cm^2) over the subsequently 125% RDN (95.48, 91.12 cm^2) and lowest was recorded in 100%RDN (88.90, 85.21 cm^2) in 30 DAS in *kharif* and *rabi* of 2021-22 and 2022-23 respectively. Two years of research observed that 100% - 150% RDN showed its phenomenal development of leaf area due to the accessibility of nitrogen in sufficient amount favored for the cell division andelongation and subsequent growth upto vegetative phase, there after a slight decline due to shift in nutrient source sink for

flowering. Which were in line with Gantayat *et al.* [7]. The interaction effect was found to be not significant at 30 DAS

3.3 Leaf Chlorophyll Content (SPAD Reading)

At 30 DAS, Growing of greengram as a preceding crop with 100% RDN had recorded significantly higher leaf chlorophyll content (23.33, 23.03) in *rabi* maize than greengram with 75%RDN (21.76, 21.20) and soybean 100 and 75% RDN and further lower chlorophyll content was recorded in groundnut with 75% RDN in *kharif* and application of 150% RDN in zero-till *rabi* maize (17.65, 17.28) in two years. Thus the overall Leaf chlorophyll content showedincreased trends after sowing in both years as the amount of residual activity on the crop stand enhanced the source- sink relation that influenced the photosynthesis activity in the leaves upto vegetative stage.

From the study in both years *i.e.* 2021-22 and 2022-23, at 30 DAS that data showed that significantly higher leaf chlorophyll content (SPAD reading) seen in F3: 150% RDN (22.6, 22.41) than F2: 125% RDN (20.60, 20.14) and lowed leaf chlorophyll content was reported in F1:100%RDN (18.31, 17.88) respectively. Thus from the statistically data the increased doses of nitrogen levels helped in effective leaf development at middle and upper portion where the greater part of photosynthesis takes place that encouraged for the higher reading. Finding were in-line with Raghavendra *et al.* [8]. The interaction effect of residual *kharif* legumes and nitrogen levels on *rabi* maize were not significant at 30 DAS.

3.4 Yield and Yield Attributes

From the research study in both years of 2021-22 and 2022-23, the yield and yield attributes were recorded and were mentioned in Table 2.

3.5 Cob Length (cm)

Greengram residues with 100% RDN on *rabi* maize sequence had significantly higher cob length (18.62, 18.35 cm) than greengram with 75% RDN (17.66, 17.33 cm), soybean 100% RDN (16.79, 16.51 cm), soybean 75% RDN (15.73, 15.45 cm) on *rabi* maize, further lowest cob length was revealed in groundnut 75% RDN (14.41 13.95 cm) in *kharif* followed by *rabi* maize in both years *i.e.* 2021-22 and 2022-23. With respect to levels of nitrogen was statistically

Table 1. Effect of preceding *kharif* legume residue and nitrogen levels on growth parameters at 30 DAS of zero-till *rabi* maize during 2021 and 2022

Treatments	Plant height (cm)			Leaf area (m^2)			Leaf chlorophyll content (SPAD reading)		
Cropping sequence	**2021**	**2022**	**Mean**	**2021**	**2022**	**Mean**	**2021**	**2022**	**Mean**
C1N1: Groundnut100 - maize	29.33	28.00	28.67	82.38	75.68	79.03	19.00	18.25	18.63
C1N2: Groundnut75 - maize	25.33	24.33	24.83	72.01	63.40	67.71	17.65	17.28	17.47
C2N1: Soybean100 - maize	33.32	32.13	32.73	100.50	97.21	98.86	21.03	20.15	20.59
C2N2: Soybean75 - maize	31.00	30.33	30.67	92.31	89.22	90.77	19.65	19.16	19.41
C3N1: Greengram100 - maize	37.33	36.00	36.67	116.75	117.08	116.92	23.33	23.03	23.18
C3N2: Greengram75 - maize	34.33	32.67	33.50	110.76	107.84	109.30	21.76	21.20	21.48
SEm±	0.31	0.20	-	1.62	2.46	-	0.20	0.30	-
C.D. (P=0.05)	0.97	0.64	-	5.11	7.75	-	0.63	0.94	-
Nitrogen levels									
F1: 100% RDN	29.17	27.83	28.50	88.90	85.21	87.06	18.31	17.88	18.10
F2: 125% RDN	31.67	30.83	31.25	95.48	91.12	93.30	20.60	20.14	20.37
F3: 150% RDN	34.67	33.17	33.92	102.97	98.88	100.93	22.76	22.41	22.59
SEm±	0.15	0.17	-	1.72	1.49	-	0.13	0.28	-
C.D. (P=0.05)	0.45	0.51	-	5.03	4.35	-	0.39	0.82	-
Interaction effect									
SEm±	0.38	0.43	-	4.22	3.65	-	0.36	0.54	-
C.D. (P=0.05)	NS	NS	-	NS	NS	-	NS	NS	-

higher when applied with 150% RDN in zero-till *rabi* maize (17.47, 1.19 cm) than 125% RDN (16.46, 16.14 cm) and lowest was seen with 100% RDN (15.35, 15.02 cm) in succeeding maize cropping sequence in 2021-22, 2022-23 of *kharif* and *rabi*. With the added nutrient, residual activity that encouraged the mobilization and utilization at the cob development and increase in the length compared to lower doses and even in high C:N residues. Similar findings were also reported by Prabhavathi et al. [9].

3.6 Girth of Cob (cm)

Data at two years of research, greengram with applied 100% RDN-maize had recorded significantly higher girth of cob (16.49, 16.05 cm) over the successive greengram with 75% RDN (15.39, 15.14 cm), soybean with 100% RDN (14.67, 14.33 cm) and lowest was recorded in groundnut with 75% RDN- maize (12.15, 11.79 cm) cropping system. From the study in both years, application of 150%RDN in zero-till *rabi* maize showed significantly higher with cob girth (15.43, 15.04 cm) than 125% RDN (14.26, 13.91 cm) and further lowest cob girth was recorded in 100% RDN in *rabi* maize (13.00, 12.70 cm) respectively. Further with the higher doses and residual retention in maize enhanced the crop growth and elongated horizontal and vertical dimension (length and girth of the cob). Similar research findings are corroborated by Pasha *et al.,*[10]..

3.7 Grain Yield (Kg ha^{-1})

Throughout the study of two years, residues of *kharif* legume crops along with varied nitrogen levels notably impacted the grain yield of *rabi* maize under zero-till conditions. This influence on grain yield was consistent across both years (Table 2).

Throughout the study of two years, residues of *kharif* legume crops like greengram with 100% RDN recorded higher kernel yield (9193, 9089 kg ha-1) than greengram with 75% RDN (8480, 8302 kg ha-1), soybean with 100% RDN (8073, 8192 kg ha-1), soybean with 75% RDN (7798, 7622 kg ha-1) and lowest was recorded in 75% RDN (6963, 6804 kg ha-1) on zero-till *rabi* maize. This pattern was consistent across both years of the experiment.

Table 2. Effect of preceding *kharif* legume residue and nitrogen levels on yield attributes and yield of zero-till *rabi* maize during 2021-22 and 2022-23

Treatments	Cob Length (cm)			Girth of cob (cm)			Grain Yield (kg ha^{-1})		
Cropping sequence	**2021**	**2022**	**Mean**	**2021**	**2022**	**Mean**	**2021**	**2022**	**Pooled**
C1N1: Groundnut100 - maize	15.15	14.89	15.02	13.12	12.78	12.95	7957	7755	7856
C1N2: Groundnut75 - maize	14.41	13.95	14.18	12.15	11.79	11.97	6963	6804	6884
C2N1: Soybean100 - maize	16.79	16.51	16.65	14.67	14.33	14.50	8073	8192	8299
C2N2: Soybean75 - maize	15.73	15.45	15.59	13.46	13.10	13.28	7798	7622	7710
C3N1: Greengram100 - maize	18.62	18.35	18.49	16.49	16.05	16.27	9193	9089	9141
C3N2: Greengram75 - maize	17.66	17.33	17.50	15.39	15.14	15.27	8480	8302	8391
SEm±	0.15	0.15	-	0.10	0.09	-	61	35	16
C.D. (P=0.05)	0.48	0.46	-	0.33	0.30	-	191	102	52
Nitrogen levels									
F1:100% RDN	15.35	15.02	15.19	13.00	12.70	12.85	7407	7229	7318
F2:125% RDN	16.46	16.14	16.30	14.26	13.91	14.09	8059	8054	8140
F3:150% RDN	17.47	17.19	17.33	15.43	15.04	15.24	8766	8599	8682
SEm±	0.11	0.09	-	0.10	0.09	-	39	35	30
C.D. (P=0.05)	0.32	0.26	-	0.29	0.27	-	112	101	86
Interaction effect									
SEm±	0.27	0.22	-	0.24	0.22	-	153	143	141
C.D. (P=0.05)	NS	NS	-	NS	NS	-	475	430	425

Table 3. Interaction effect of preceding *kharif* legume residue and nitrogen levels on Grain yield (kg ha^{-1}) of zero-till *rabi* maize during 2021-22 and 2022-23

Treatments Kernel yield							
2021	**Cropping sequence**						
Nitrogen levels	C1N1	C1N2	C2N1	C2N2	C3N1	C3N2	Mean
F1: 100% RDN	7451	6148	7818	6905	8394	7727	7407
F2: 125% RDN	7966	6988	7394	7970	9386	8651	8059
F3: 150% RDN	8454	7754	9007	8519	9799	9060	8766
Mean	7957	6963	8073	7798	9193	8480	
Factor	Cropping sequence (C)		Nitrogen (N)	Cropping sequence at same level of nitrogen		Nitrogen at same level of cropping system	
SEm±	61		39	153		168	
C.D. (P=0.05)	191		112	475		486	

Treatments Kernel yield							
2022	**Cropping sequence**						
Nitrogen levels	C1N1	C1N2	C2N1	C2N2	C3N1	C3N2	Mean
F1: 100% RDN	7246	6001	7576	6742	8287	7519	7229
F2: 125% RDN	7699	6933	8154	7811	9276	8453	8054
F3: 150% RDN	8319	7479	8846	8314	9704	8934	8599
Mean	7755	6804	8192	7622	9089	8302	
Factor	Cropping sequence (C)		Nitrogen (N)	Cropping sequence at same level of nitrogen		Nitrogen at same level of cropping system	
SEm±	35		35	143		156	
C.D. (P=0.05)	102		101	430		451	

Table 4. Interaction effect of preceding *kharif* legume residue and nitrogen levels on Grain yield (kg ha^{-1}) of zero-till *rabi* maize pooled data during 2021-22 and 2022-23

	Treatments						
Kernel yield- Pooled	**Cropping sequence**						
Nitrogen levels	C1N1	C1N2	C2N1	C2N2	C3N1	C3N2	Mean
F1: 100% RDN	7348	6074	7697	6824	8340	7623	7318
F2: 125% RDN	7832	6961	8274	7890	9331	8552	8140
F3: 150% RDN	8387	7616	8927	8416	9752	8997	8682
Mean	7856	6884	8299	7710	9141	8391	
Factor	Cropping sequence (C)		Nitrogen (N)	Cropping sequence at same level of nitrogen		Nitrogen at same level of cropping system	
SEm±	16		30	141		154	
C.D. (P=0.05)	52		86	425		446	

In both years of study, the impact of nitrogen levels on kernel yield was significantly influenced, but with the application of 150% RDN to *rabi* maize revealed higher kernel yields (8766, 8599 kg ha-1) followed by 125% RDN (8059, 8054 kg ha-1) and lowest was recorded in 100% RDN (7407, 7229 kg ha-1) (Table 2). Similar findings by reported by Wadile *et al.,* [11]

The interaction effect of preceding *kharif* legume residue and nitrogen levels on *rabi* maize revealed that, the green gram as preceding *kharif* crop with 100% RDN followed by maize with 150% RDN recorded significantly higher grain yields (9799, 9704 kg ha-1) but was onpar with *kharif* greengram with 100% RDN followed by 125% RDN in *rabi* maize (9386, 9276 kg ha-1), further greengram with 75% RDN in *kharif* with 150% RDN in *rabi* maize (9060, 8934 kg ha-1) which was similar to *kharif* soybean with 100% RDN and 150% RDN in *rabi* and lowest kernel yields was seen in groundnut with 75% RDN followed by 100% RDN (6148, 6001 kg ha-1) respectively in two years. The less soil disturbance under zero-till conditions and also immobilization of nitrogen, the maize might have showed response to higher nitrogen levels compared to lower nitrogen levels. Overall, in a system perspective 250 % and 225% levels have showed superior performance interms of yields (Table 4).

4. CONCLUSIONS

The study revealed that the cropping sequence of greengram as preceding legume in *kharif* followed by zero-till maize in *rabi* showed significant results in terms of growth and yield. Specifically, nitrogen levels at a recommended dose of 100% in *kharif* and 150% in *rabi* exhibited the superior performance, followed closely by 100%-125% RDN and 75%-150% RDN. This suggests that a balanced approach, with reduced nitrogen in the preceding season but higher doses with legume residue retention, significantly enhances crop growth phenology as well as productivity during the both years.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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