

RESEARCH

IMPACT OF RESIDUE AND NUTRIENT MANAGEMENT STRATEGIES ON THE GROWTH OF MAIZE IN A MAIZE-MUSTARD CROPPING SYSTEM

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Abstract: An investigation was conducted during 2022-23 and 2023-24 at the Research Farm, Raj Mohini Devi College of Agriculture and Research Station, Ambikapur, Chhattisgarh to examine the growth performance of maize in response to varied residue and nutrient management options. Experiment was laid out in strip plot design with three replications. The treatment consisted of twelve treatment combinations including four vertical factors *i.e.*, M₁- Residue removal, M₂- Residue incorporation, M₃- Residue incorporation + spray of microbial consortium on residue and M₄- Zero-tillage + residue retention and spray of microbial consortium on residue and three horizontal factors *i.e.*, N₁- 100% RDF of NPK (120:60:40 kg N:P₂O₅:K₂O ha⁻¹), N₂- 100% RDN and P and 50% RDK and N₃- 75 % RDF of NPK + 5 t FYM ha⁻¹. Results revealed that adoption of crop residue incorporation + spray of microbial consortium recorded significantly higher plant population, growth parameters of maize viz., plant height, number of leaves plant⁻¹, leaf area plant⁻¹, leaf area index, fresh weight and dry matter accumulation which was at par to residue incorporation and zero-tillage + residue retention and spray of microbial consortium. Similarly, significantly more plant population and growth parameters were recorded under 100% RDF as compared to others.

Keywords: FYM, Microbial consortium, Nutrient management, Residue management, Zero tillage

INTRODUCTION

Maize (*Zea mays* L.) crop regarded as a queen of cereals occupies pride place among rainy (*Kharif*) season crops in India and contributing around 24% of total cereal production. It is the crop which has great relevance as staple crop, significant yield potential and third most important cereal grain in the world after wheat and rice. Maize has the origination from the Guatemala and southern part of the Mexico. Maize assumes to have worldwide significance as a source of food, feed and diverse industrial products (Prasanna *et al.*, 2020). It is widely grown as the major crop throughout the world across a wide range of agro-climates and diverse ecological zones. In world, total area under the maize was 197.2 m ha and the total production was 1148.48 million tons with an average yield of about 5.82 tons ha⁻¹ (FAOSTAT, 2020). In India, maize occupies an area of about 9.72 million hectare and the production was 28.64 metric tonnes with average yield of 2945 kg ha⁻¹ (Anonymous, 2020a). In the state of Chhattisgarh, it has an area about 206.63 thousand ha with productivity of 2789 kg ha⁻¹ during 2019-20 (Anonymous, 2020b).

The intensive rice-wheat cropping system is posing a serious threat to the agricultural sustainability (Hoobs and Gupta, 2004) causing decline in the soil fertility, ground water table and energy crisis. This has become a major constraint in improving crop productivity. Under such circumstances, diversified maize based crop rotations along with conservation-based tillage practices such as zero-till flat and permanent bed minimizes the adverse effects of conventional tillage practices and simultaneously maintains soil fertility. Maize is the pre-dominant *kharif* crop of northern hills region of Chhattisgarh and maize-mustard is the predominant cropping system of this zone. Utilizing crop residue and conservation-based tillage can make this cropping system more profitable and also benefiting soil health. Besides these, nutrient management is the most important factor in maize-mustard cropping systems as being both the crops are exhaustive feeders of plant nutrients and following this system leads to the removal of the nutrients in the significant amount that cannot be sufficed by proper fertilizer and

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manure application which ultimately leads to the decline in the fertility of soil and the production of the system is greatly affected. It is generally necessary to use chemical fertilizers in conjunction with organic manure to increase the soil health under continuous farming. With the aim of addressing the above, the present experiment was conducted to identify an optimal residue and nutrient management strategy for enhancing the growth performance of maize.

MATERIALS AND METHODS

The experiment was conducted during 2022-23 and 2023-24 at the Research Farm, Raj Mohini Devi College of Agriculture and Research Station, Ambikapur, Chhattisgarh. The texture of the soil of experimental field was sandy-loam (*Inseptisols*) in nature, acidic in reaction, medium in organic carbon and low in available nitrogen, medium in available phosphorus and high in available potassium. Climate of the region is usually semi-arid and sub-tropical having extreme winter and summer with rainfall received from South - West monsoon which is distributed from June to October which is around 1400 mm. The maximum temperature raises up to 44°C during summer and minimum temperature drops down as low as 4-5°C during winter season. The relative humidity reaches up to 74 per cent. Experiment was laid out in strip plot design with three replications. The treatment consisted of twelve treatment combinations including four vertical factors *i.e.*, M₁- Residue removal, M₂- Residue incorporation, M₃- Residue incorporation + spray of microbial consortium on residue and M₄- Zero-tillage + residue retention and spray of microbial consortium on residue and three horizontal factors *i.e.*, N₁- 100% RDF of NPK, N₂- 100% RDN and P and 50% RDK and N₃- 75 % RDF of NPK + 5 t FYM ha⁻¹. Sowing of maize cv. NK 30 was done manually by using 20-25 kg seed ha⁻¹ by maintaining 75 cm x 20 cm spacing. Recommended dose of fertilizer of 120:60:40 kg N:P₂O₅:K₂O ha⁻¹ was applied as per the treatment in maize. Effect of above-mentioned treatments on growth behavior of maize was observed periodically and analyzed statistically.

RESULTS AND DISCUSSION

Plant population

The experiment revealed that among residue management practices, incorporating residue with a microbial consortium spray (M₃) resulted in a significantly higher maize plant population at harvest

compared to residue removal (M₁), although it was similar to residue incorporation alone (M₂) and zero-tillage with residue retention and microbial consortium spray (M₄). For nutrient management, applying 100% RDF (N₁) led to the maximum plant population, comparable to 100% RDN and P with 50% RDK (N₂), while 75% RDF of NPK plus 5 t FYM ha⁻¹ (N₃) yielded the lowest population (Table 1). The improved plant population with residue incorporation and microbial consortium spray is likely due to better soil health, nutrient availability, moisture retention, and reduced compaction. The higher plant population under 100% RDF and 100% RDN and P with 50% RDK suggests that adequate nutrients promote vigorous growth, while insufficient nutrients in N₃ may limit plant development, emphasizing the importance of balanced nutrient management. Present investigation is more or less similar to the reports of Rathore *et al.* (1998). They also noted the highest plant stand in zero tillage as compared to conventional tillage in chickpea and mustard crops.

Plant height (cm)

The data shows that maize plant height increased with crop age, peaking at 90 days after sowing (DAS) and was significantly affected by residue and nutrient management practices at various stages (Table 1). At 60 DAS, residue incorporation with microbial consortium spray (M₃) resulted in taller plants, similar to residue incorporation alone (M₂) and zero-tillage with residue retention and microbial consortium spray (M₄). For nutrient management, 100% RDF (N₁) produced taller plants than 75% RDF with FYM (N₃), with a consistent trend observed at 30, 60, 90 DAS, and harvest.

Number of leaves plant⁻¹

At 60 DAS, residue incorporation with microbial consortium spray (M₃) led to the maximum number of leaves per plant, comparable to residue incorporation alone (M₂) and zero-tillage with residue retention and microbial consortium spray (M₄), while residue removal (M₁) resulted in the fewest leaves. For nutrient management, 100% RDF (N₁) produced the most leaves, similar to 100% RDN and P with 50% RDK (N₂), and 75% RDF with FYM (N₃) had the least, with a consistent trend at 90 DAS and harvest (Table 1).

Leaf area plant⁻¹ (cm²)

At 60 DAS, the maximum leaf area per plant was achieved with residue incorporation and microbial consortium spray (M₃), similar to residue incorporation alone (M₂) and zero-tillage with residue retention and microbial consortium spray

(M₄), while residue removal (M₁) resulted in the smallest leaf area. For nutrient management, 100% RDF (N₁) led to the largest leaf area, and 75% RDF with FYM (N₃) resulted in the smallest, with this trend continuing at 90 DAS and until harvest (Table 2).

Leaf area index

The leaf area index (LAI) of maize was significantly influenced by different residue and nutrient management practices, increasing sharply until 60 days after sowing (DAS) (Table 2). At 60 DAS, residue incorporation with microbial consortium spray (M₃) had the highest LAI, similar to residue incorporation alone (M₂) and zero-tillage with residue retention and microbial consortium spray (M₄), while residue removal (M₁) had the lowest. For nutrient management, 100% RDF (N₁) resulted in the highest LAI, and 75% RDF with FYM (N₃) had the lowest. This trend continued at 90 DAS and at harvest.

Fresh weight (g plant⁻¹)

The fresh weight of maize increased with crop growth stages up to harvest (Table 3). At 30 DAS, residue incorporation with microbial consortium spray (M₃) had the highest fresh weight, similar to residue incorporation alone (M₂) and zero-tillage with residue retention and microbial consortium spray (M₄), while residue removal (M₁) had the lowest. For nutrient management, 100% RDF (N₁) resulted in the highest fresh weight at all stages, and 75% RDF with FYM (N₃) had the lowest. This trend was consistent at 60, 90 DAS, and harvest.

Dry weight (g plant⁻¹)

Dry matter accumulation per plant increased with crop age up to harvest (Table 3). At 60, 90 DAS and harvest, residue incorporation with microbial consortium spray (M₃) produced the maximum dry matter, similar to residue incorporation alone (M₂) and zero-tillage with residue retention and microbial consortium spray (M₄), while residue removal (M₁) produced the least. For nutrient management, 100% RDF (N₁) accumulated the maximum dry matter, and 75% RDF with FYM (N₃) accumulated the least, with this trend consistent across both years and on average.

Crop growth rate (g plant⁻¹ day⁻¹) and relative growth rate (g g⁻¹ day⁻¹)

Crop growth rate (CGR) and relative growth rate (RGR) were influenced considerably by residue and nutrient management practices (Fig. 1 and Fig. 2).

Residue incorporation with microbial consortium spray (M₃) generally increased CGR and RGR, followed by residue incorporation alone (M₂) and zero-tillage with residue retention and microbial consortium spray (M₄). However, residue removal (M₁) showed the highest RGR from 60 to 90 DAS. For nutrient management, 100% RDF (N₁) increased CGR and RGR up to 60 DAS, while 75% RDF with FYM (N₃) showed the highest RGR from 60 DAS to harvest. Both CGR and RGR peaked early in the growing season and declined after 60 DAS.

The study demonstrates that, zero-tillage combined with residue retention and microbial consortium spray enhances maize growth, including height, leaf number, leaf area index, and biomass, by conserving soil structure and moisture, improving nutrient availability, and fostering beneficial soil organisms (Kumar et al., 2018). Among nutrient management options, 100% RDF promotes robust morphological performance by providing balanced essential nutrients, with nitrogen enhancing leaf and stem growth, phosphorus supporting root development, and potassium aiding metabolism and stress tolerance (Mahala et al., 2006; Ponmozhi et al., 2019; Yadav et al., 2022; Ramesh et al., 2023). These findings highlight the importance of integrated soil and nutrient management for optimizing maize growth and productivity.

CONCLUSION

The study concludes that, the integration of crop residue incorporation with microbial consortium spray significantly enhanced maize plant population and growth attributes, including height, leaf count per plant, leaf area per plant, leaf area index, fresh weight, and dry matter accumulation. These improvements were comparable to those observed with residue incorporation and zero-tillage combined with residue retention and microbial consortium spray. Similarly, the application of 100% recommended dose of fertilizer (RDF) resulted in a significantly greater plant population and superior growth parameters relative to other nutrient management strategies.

Table 1. Plant population, plant height and number of leaves of maize as influenced by crop residue and nutrient management in maize – mustard cropping system

Treatment	Plant population (No. ha ⁻¹)	Plant height (cm)									Number of leaves plant ⁻¹											
		At harvest			60 DAS			90 DAS			At harvest			60 DAS			90 DAS			At harvest		
		2022	2023	Mean	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
Crop residue management																						
M ₁ :	Residue removal	56753.7	58647.2	57700.5	200.6	184.7	192.7	203.3	187.6	195.5	192.0	188.0	190.0	12.5	11.1	11.8	11.2	11.0	11.1	10.7	10.3	10.5
M ₂ :	Residue incorporation	60962.0	62855.6	61908.8	216.2	205.0	210.6	220.3	207.4	213.8	214.4	205.5	210.0	14.0	12.2	13.1	12.7	11.9	12.3	12.0	11.4	11.7
M ₃ :	Residue incorporation + spray of microbial consortium	62401.9	64010.2	63206.0	222.6	211.2	216.9	228.7	216.9	222.8	220.2	215.5	217.8	14.3	12.9	13.6	12.8	12.6	12.7	12.2	12.0	12.1
M ₄ :	Zero-tillage + residue retention and spray of microbial consortium	59926.9	62346.3	61136.6	215.4	202.4	208.9	217.5	204.3	210.9	208.5	190.9	199.7	13.8	12.1	12.9	12.6	11.8	12.2	11.8	11.1	11.4
	SEM±	1052.22	1033.73	609.65	4.19	5.14	2.51	4.62	5.52	3.47	5.41	5.53	5.26	0.27	0.31	0.25	0.33	0.20	0.21	0.23	0.31	0.15
	CD (P=0.05)	3641.15	3577.18	2109.65	14.51	17.78	8.68	15.98	19.09	12.00	18.71	19.14	18.21	0.92	1.06	0.85	1.12	0.70	0.74	0.78	1.09	0.51
Nutrient management																						
N ₁ :	100% RDF	63141.7	64292.4	63717.0	224.2	214.3	219.2	228.4	216.9	222.6	218.8	212.9	215.8	14.2	12.8	13.5	13.0	12.6	12.8	12.1	12.0	12.1
N ₂ :	100% RDN and P and 50% RDK	59184.0	61181.3	60182.6	214.6	203.8	209.2	218.1	206.5	212.3	213.2	201.9	207.5	13.9	12.5	13.2	12.6	12.2	12.4	12.0	11.2	11.6
N ₃ :	75 % RDF of NPK + 5 t FYM ha ⁻¹	57707.6	60420.8	59064.2	202.4	184.4	193.4	205.8	188.8	197.3	194.4	185.2	189.8	12.8	11.0	11.9	11.4	10.6	11.0	10.9	10.4	10.6
	SEM±	1016.12	770.76	520.20	3.54	3.17	2.45	4.26	5.36	2.78	4.80	4.45	2.42	0.24	0.21	0.16	0.24	0.21	0.14	0.19	0.27	0.20
	CD (P=0.05)	3989.77	3026.37	2042.57	13.89	12.45	9.61	16.71	21.03	10.90	18.84	17.48	9.50	0.93	0.84	0.62	0.96	0.82	0.54	0.75	1.05	0.78

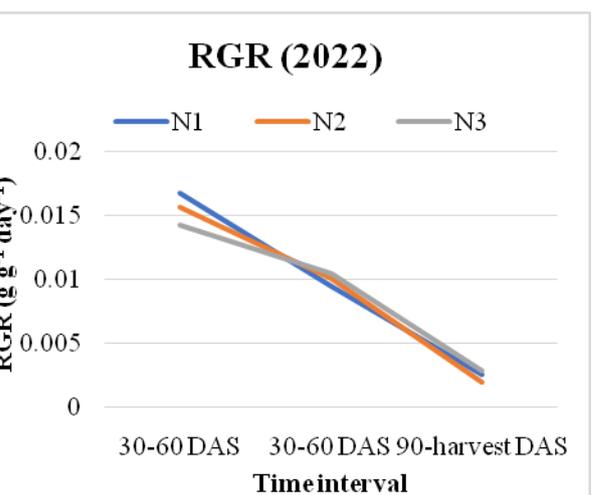
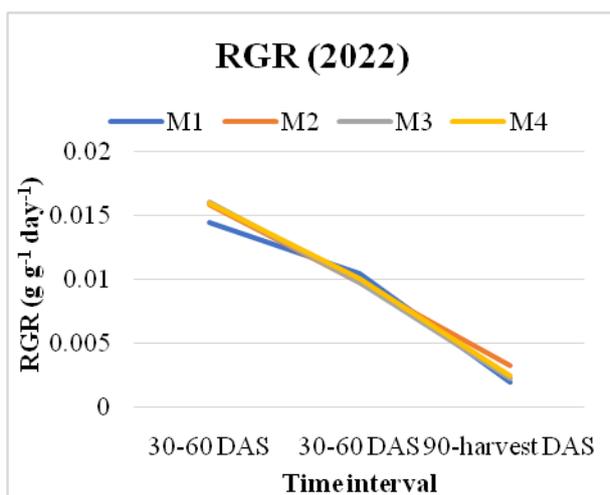
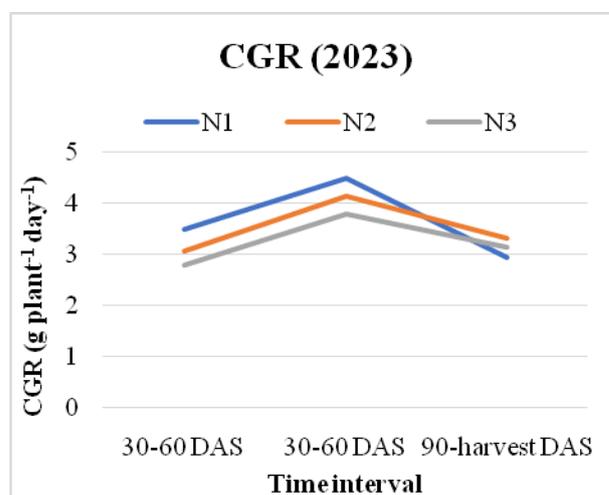
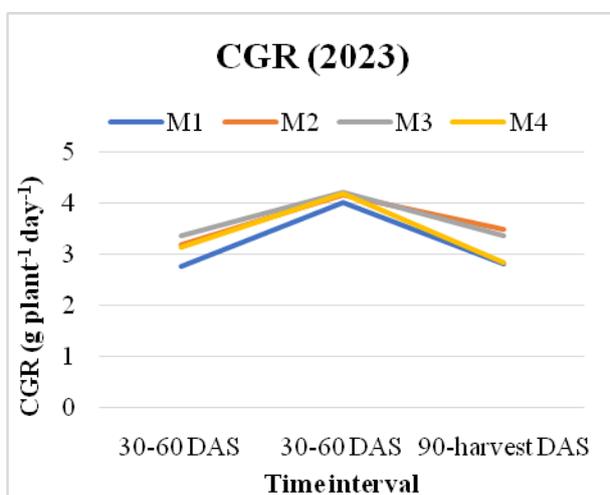
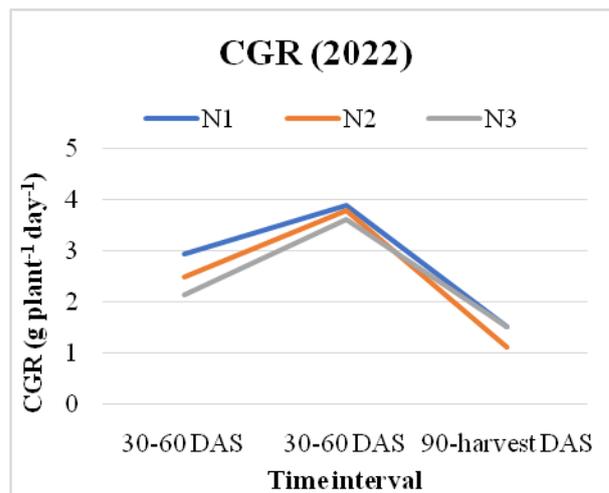
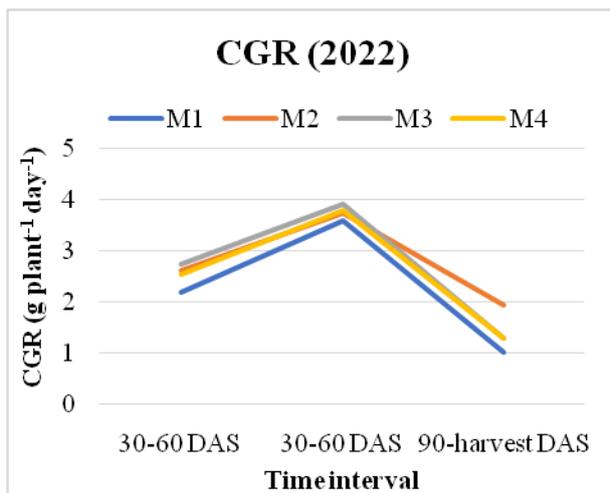
Table 2. Leaf area and leaf area index of maize as influenced by crop residue and nutrient management in maize – mustard cropping system

Treatment		Leaf area plant ⁻¹ (cm ²)									Leaf area index (LAI)								
		60 DAS			90 DAS			At harvest			60 DAS			90 DAS			At harvest		
		2022	2023	Mean	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
Crop residue management																			
M ₁ :	Residue removal	10056.5	6279.8	8168.2	8895.0	6462.6	7678.8	6236.6	6091.4	6164.0	6.7	4.2	5.4	5.9	4.3	5.1	4.2	4.1	4.1
M ₂ :	Residue incorporation	11088.9	7465.7	9277.3	9948.8	7011.3	8480.0	7147.5	6670.6	6909.0	7.4	5.0	6.2	6.6	4.7	5.7	4.8	4.4	4.6
M ₃ :	Residue incorporation + spray of microbial consortium	11574.4	7723.9	9649.2	10216.6	7413.0	8814.8	7451.0	7016.0	7233.5	7.7	5.1	6.4	6.8	4.9	5.9	5.0	4.7	4.8
M ₄ :	Zero-tillage + residue retention and spray of microbial consortium	10758.6	7282.5	9020.5	9798.0	6945.9	8372.0	7071.6	6537.5	6804.6	7.2	4.9	6.0	6.5	4.6	5.6	4.7	4.4	4.5
	SEM±	226.58	282.40	161.61	256.69	166.90	132.09	187.47	168.39	129.07	0.15	0.19	0.11	0.17	0.11	0.09	0.12	0.11	0.09
	CD (P=0.05)	784.09	977.22	559.24	888.25	577.53	457.09	648.73	582.70	446.63	0.52	0.65	0.37	0.59	0.39	0.30	0.43	0.39	0.30

Nutrient management																			
N ₁ :	100%RDF	11890.3	7823.9	9857.1	10497.6	7479.6	8988.6	7504.3	7203.1	7353.7	7.9	5.2	6.6	7.0	5.0	6.0	5.0	4.8	4.9
N ₂ :	100% RDN and P and 50% RDK	10675.2	7048.3	8861.7	9556.8	6831.4	8194.1	6831.6	6345.6	6588.6	7.1	4.7	5.9	6.4	4.6	5.5	4.6	4.2	4.4
N ₃ :	75 % RDF of NPK + 5 t FYM ha ⁻¹	10043.4	6691.7	8367.5	9089.3	6563.7	7826.5	6594.1	6187.9	6391.0	6.7	4.5	5.6	6.1	4.4	5.2	4.4	4.1	4.3
	SEM±	295.94	187.60	135.13	158.00	127.23	114.82	148.83	159.92	136.81	0.20	0.13	0.09	0.11	0.08	0.08	0.10	0.11	0.09
	CD (P=0.05)	1161.99	736.60	530.60	620.38	499.58	450.83	584.36	627.94	537.17	0.77	0.49	0.35	0.41	0.33	0.30	0.39	0.42	0.36

Table 3. Fresh and dry weight of maize as influenced by crop residue and nutrient management in maize – mustard cropping system

Treatment		Fresh weight (g plant ⁻¹)									Leaf area index (LAI)								
		60 DAS			90 DAS			At harvest			60 DAS			90 DAS			At harvest		
		2022	2023	Mean	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
Crop residue management																			
M ₁ :	Residue removal	414.7	440.5	427.6	433.1	443.2	438.2	460.4	491.4	475.9	103.4	106.8	105.1	210.8	226.8	218.8	233.8	249.2	241.5
M ₂ :	Residue incorporation	469.3	508.0	488.7	491.0	497.1	494.1	527.5	526.3	526.9	118.2	120.9	119.6	230.4	246.0	238.2	274.9	273.8	274.4
M ₃ :	Residue incorporation + spray of microbial consortium	482.3	514.1	498.2	505.4	515.7	510.5	520.5	535.9	528.2	122.5	128.2	125.4	239.6	254.7	247.1	269.2	281.6	275.4
M ₄ :	Zero-tillage + residue retention and spray of microbial consortium	458.0	499.0	478.5	471.3	487.6	479.4	516.0	517.7	516.9	114.2	118.3	116.3	227.9	243.6	235.8	257.6	266.3	261.9
	SEM±	10.9	8.54	5.84	11.16	9.49	9.16	9.33	8.68	3.78	3.11	3.22	2.68	4.76	5.06	3.39	6.33	5.72	4.89
	CD (P=0.05)	37.8	29.6	20.2	38.6	32.8	31.7	32.3	30.0	13.1	10.8	11.1	9.28	16.5	17.5	11.7	21.9	19.8	16.9
Nutrient management																			
N ₁ :	100%RDF	489.5	542.7	516.1	516.0	524.6	520.3	548.0	554.5	551.3	127.4	131.0	129.2	243.8	266.0	254.9	278.5	289.4	284.0
N ₂ :	100% RDN and P and 50% RDK	454.3	490.0	472.2	470.7	476.3	473.5	497.1	509.6	503.4	113.4	117.2	115.3	226.7	241.3	234.0	252.0	267.8	259.9
N ₃ :	75 % RDF of NPK + 5 t FYM ha ⁻¹	424.4	438.5	431.4	438.9	456.8	447.9	473.2	489.4	481.3	103.0	107.5	105.2	211.1	221.0	216.0	246.1	246.0	246.1
	SEM±	8.08	9.55	6.64	9.93	11.12	8.73	10.5	7.05	5.76	2.26	2.33	1.05	4.00	4.17	2.91	5.60	4.56	3.02
	CD (P=0.05)	31.7	37.5	26.1	39.0	43.7	34.3	41.2	27.7	22.6	8.86	9.16	4.12	15.7	16.4	11.4	22.0	17.9	11.8



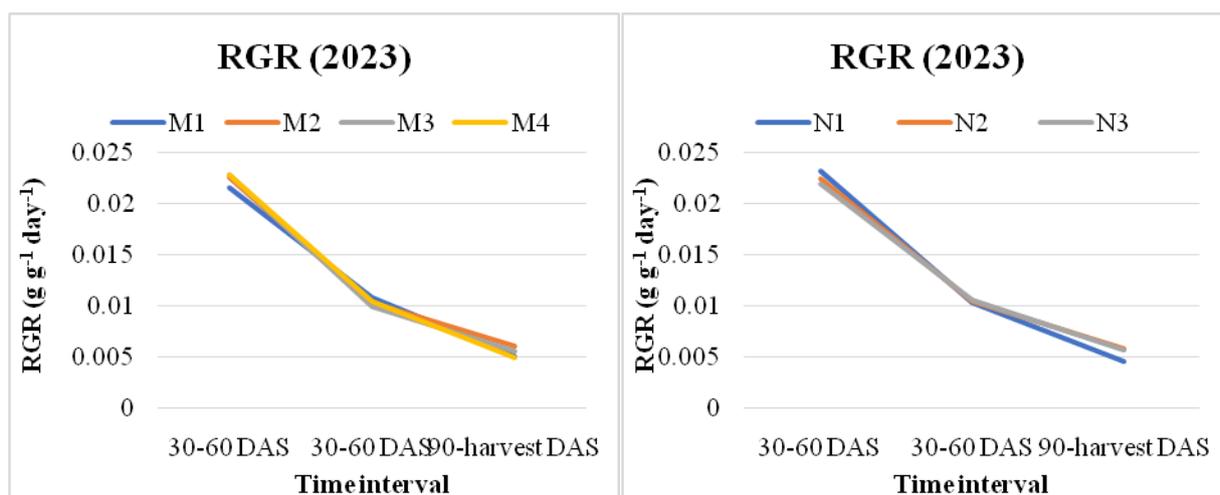


Fig. 2. Relative growth rate of maize as influenced by crop residue and nutrient management in maize – mustard cropping system

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