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Effect of Nitrogen Sources, doses and Split applications on yield and economics of maize (Zea mays L.) in the Malwa region of Madhya Pradesh (India)

*Arun Joshi, **J. K. Gupta, ***S. K. Choudhary, ****S. Mujalde and**** Manisha Garg

Head, NLRI,Ratlam, MP, **Professor,Agronomy,College of Agriculture, Indore,MP,***Professor, Ag.Economics, M.G.C.G.V.V.Chitrakoot, Satna, MP**** Assistant Professor,Agronomy,College of Agriculture, Indore,MP*****Specialist , NLRI,Ratlam, MP*

Abstract: *Maize is a important crop for food, feed and industrial utilization and grown in 7.8 M ha land with 14.05 M tones of production and 1885 kg/ha productivity in India. But its productivity is very low in Madhya Pradesh and India due to wide range of production constraints, such as limited irrigation facilities and low Nutrient use efficiency. Experiment was conducted in Kharif seasons of 2009-10 and 2010-11 at Research Farm, National Livelihood Resource Institute, Ratlam (Madhya Pradesh) in the typical medium black clayey soil. The rainfall observed during crop periods was 874.4 and 510 mm in 2009-10 and 2010-11, respectively. The soil was low in organic carbon and available nitrogen , medium in available phosphorus and medium in available potassium with a pH of 7.76 and EC of 0.26 dSm^{-1}*

The experiment consisted of twenty seven treatment combinations of three levels each of the three factors viz. levels, source and schedules of nitrogen application viz., 50, 75 and 100 kg N/ha in the form of Prilled urea, Granular urea and Neem coated urea applied either in single dose at sowing or in two split (basal and 25 DAS) or in three split (basal, 25 and 45 DAS). A common dose of 40 kg P_2O_5 and 40 kg K_2O/ha was applied at sowing. The experiment was laid out in completely randomized block design with 3 replications. Level, scheduling and source of nitrogen significantly interacted for seed yield per hectare. $N_3T_3S_3$ (100 kg N/ha through Neem coated urea in three splits) produced significantly maximum seed yield 6133.42, 6387.33 and 6260.37 kg/ha during both the year. The B: C ratios of 5.33, 6.07 and 5.7 were found highest under the treatment combinations $N_3S_2T_3$ followed by $N_3S_3T_3$ during 2009, 2010. On the basis of the two years experimentation, it can be achieving the higher yields with better monetary returns from maize variety JM-216 through Neem coated urea @ 100 kg/ha in 3 splits doses i.e. basal, 25 and 45 DAS.

I. Introduction

Maize is a crop par excellence for food, feed and industrial utilization and grown in 7.8 M ha land with 14.05 M tones of production and 1885 kg/ha productivity in India under irrigated to Semi-arid conditions. It provides the nutritional security due to its high nutritive values. The low productivity of maize in India is associated with a wide range of production constraints, among them low nitrogen use efficiency is a major constraint. While cultivating the maize crop, the farmers come across various problems like less availability or non availability of the seed, improper irrigation facilities, use of fertilizers, availability of farm yard manure, etc. Among these factors, the imbalanced use of fertilizers especially nitrogen is a major factor. Nitrogen (N) is often the most limiting factor in crop production. Hence, application of fertilizer nitrogen results in higher biomass yields and protein yield and concentration in plant tissue is commonly increased. Nitrogen often affects amino acid composition of protein and in turn its nutritional quality. In maize, abundant supply of nitrogen decreases the relative proportion of lysine and threonine, thus, reducing the biological value of the protein. Increasing nitrogen supply generally improves kernel integrity and strength, resulting in better milling properties of the grain (Blumenthal *et al*., 2008). Nitrogen is in high demand throughout the growing season. In the first 25 days of a maize plants growth, it will absorb 8% of its total Nitrogen. This is critical because the corn plant determines the number of kernel rows in the first 25 days of growth. The number of kernel rows can dramatically impact yield, so placement in the root zone is extremely important. Maize is a highly exhaustive crop and it requires high nutrient application particularly nitrogen. Increasing N –fertilizer use efficiency and reducing the leaching losses of nitrogenenous fertilizers are some of the options to lower the doses of nitrogen in maize. Application of nitrogenous fertilizers as top dressings at various crop stages, modifying the physical properties of fertilizer granules are possible ways to meet out the options besides lowering the cost of production. Keeping these facts in view, the experiment was conducted in *kharif* seasons of 2009-10 and 2010-11 in Malwa plateau agro-climatic zone of Madhya Pradesh.

II. Material And Methods

The experiment was conducted during *Kharif* season of 2009-10 and 2010-11 at Research Farm, National Livelihood Resource Institute, Ratlam (Madhya Pradesh). The topography of field was uniform and gentle slope with adequate drainage. It has subtropical climate with a temperature range of 25.5^{o}C to 38.2^{o}C and 10.7^{o}C to 26.5^{o}C in summer and winter season respectively. This region belongs to semi arid condition with an average annual rainfall of 960 mm. However the rainfall observed during crop periods was 874.4 and 510 mm in 2009-10 and 2010-11, respectively. The soil of the field was a typical medium black clayey soil. The soil was low in organic carbon and available nitrogen (184.5 kg/ha), medium in available phosphorus (10.10 kg/ha) and medium in available potassium (338.6 kg/ha) with a pH of 7.76 and EC of 0.26 dSm^{-1}

The experiment consisting of the 27 treatment combinations of The experiment consisted of twenty seven treatment combinations of three levels each of the three factors viz. levels, source and schedules of nitrogen application, laid in completely randomized block design replicated three times. The treatments consisted of 50, 75 and 100 kg N/ha in the form of Prilled urea, Granular urea and Neem coated urea applied either in single dose at sowing or in two split (basal and 25 DAS) or in three split (basal, 25 and 45 DAS). A common dose of 40 kg P_2O_5 and 40 kg K_2O/ha was applied at sowing. Full dose of P_2O_5 and K_2O was given through complex fertilizer and the remaining quantity of N as per treatment was given through Granular urea, Prilled urea and Neem coated urea. The experiment was carried out in a Factorial Randomized block design and analysed statistically as per procedure suggested by Panse and Sukhatme (1978). Standard package of practices and observation patterns were followed during both of the years of experimentations.

III. Results And Discussions

The Table 1 revealed that the yield and of maize were significantly higher with the application of nitrogen through Neem coated urea than the Granular urea and Prilled urea. This may be due to the fact that coating of urea decreases the leaching loses and provide more nitrogen to the plant (Chaudhari *et al.*, 2006). Similar findings were also obtained by Palled and Shenoy (2000).

Yield:

Grain yield:

Based on the area of net plot, the plot wise seed yield (kg) were recorded and converted into kg/ha by multiplying conversion factor 833.33 and presented in Table 1.

The analysis of variance showed that the level and scheduling of nitrogen caused significant differences in the seed yield of maize individually. However, the interaction effects were not found significant statistically.

Table 1: Grain and straw yield of maize as influenced by different nitrogen sources, levels and scheduling

Treatment	Grain yield (kg/ha)			Straw yield (kg/ha)		
	2009	2010	Pooled	2009	2010	Pooled
Source of nitrogen						
S_1: Prilled urea	5265.34	5225.55	5245.45	8755.53	8713.40	8734.46
S_2: Granular urea	5516.98	5561.54	5539.26	9115.13	9199.70	9157.41
S_3: NC urea	5552.66	5585.00	5568.83	9212.30	9250.17	9231.24
SEm±	**75.53**	**82.11**	**77.20**	**119.20**	**134.62**	**123.04**
C.D. (at 5%)	**214.35**	**233.00**	**219.08**	**338.26**	**382.02**	**349.16**
Level of nitrogen						
N_1: 50 kg N/ha	5286.62	5273.18	5279.90	8772.52	8812.10	8792.31
N_2: 75 kg N/ha	5386.52	5428.76	5407.64	8940.01	8996.35	8968.18
N_3: 100 kg N/ha	5661.84	5670.15	5665.99	9370.43	9354.82	9362.62
SEm±	**75.53**	**82.11**	**77.20**	**119.20**	**134.62**	**123.04**
bC.D. (at 5%)	**214.35**	**233.00**	**219.08**	**338.26**	**382.02**	**349.16**
Scheduling of nitrogen						
T_1: Basal only	5205.24	5219.49	5212.37	8606.05	8688.24	8647.15
T_2: 2-Splits	5473.80	5521.88	5497.84	9084.68	9108.80	9096.74
T_3: 3-splits	5655.94	5630.72	5643.33	9392.23	9366.22	9379.23
SEm±	**75.53**	**82.11**	**77.20**	**119.20**	**134.62**	**123.04**
C.D. (at 5%)	**214.35**	**233.00**	**219.08**	**338.26**	**382.02**	**349.16**

Among the various sources of nitrogen, S_3: neem coated urea produced highest seed yield of 5552.66, 5585 and 5568.83 kg/ha during 2009, 2010 and in pooled data analysis respectively, followed the grain yield of 5516.98, 5561.54 and 5539.26 kg/ha under nitrogen source S_2: Granular urea. Both the treatments were failed to differ statistically, however S_3: NC urea gave 0.65%, 0.42% and 0.53% higher production as compared to S_2: Granular urea. The significantly lowest yield of 5265.34, 5225.55 and 5245.45 kg/ha was recorded under nitrogen source S_1: Prilled urea respectively. The grain yield under S_2: Granular urea was recorded 5.46%, 6.88% and 6.16% higher over S_1: Prilled urea during 2009, 2010 and in pooled data analysis.

As the doses of nitrogen are concern, the effect of 100 kg/ha nitrogen application (N_3) on grain production was found significantly more than to the effect of 75 kg N/ha (N_2). The Increase in seed yield as a result of 100 kg N/ha over 75 kg N/ha were 5.11%, 4.45% and 4.78% during the years 2009, 2010 and in pooled data analysis. The 50 kg/ha application of N produced lowest grain yield of 5286.62, 5273.18 and 5279.9 kg/ha, which were 7.10%, 7.53% and 7.31% lower than the yield achieved under N_3: 100 kg N/ha.

Under the schedule of nitrogen application, application of nitrogen in three splits (T_3: 3-splits applications (basal, 25 and 45 DAS)) registered the maximum seed yield of 5655.954, 5630.72 and 5643.33 kg/ha during both the years and in pooled data analysis which were 3.33%, 1.97% and 2.65 % higher over the yield achieved under T_2: 2-splits applications (basal and 25 DAS) respectively, but these differences were not found significant. Lowest seed yield of 5205.24, 5219.49 and 5212.37 kg/ha was recorded under T_1: only basal application of nitrogen, which was 8.66%, 7.88% and 8.27% lower than yield achieved under T_3: 3-splits applications (basal, 25 and 45 DAS).

Interactive effect of level, scheduling and source of nitrogen application on seed yield per hectare were not found significant. However, treatment combination $N_3T_3S_3$ and $N_3T_3S_2$ were registered to produce the higher grain yield.

Straw yield:

The data recorded on straw yield in kg/plot was converted into straw yield in q/ha by multiplying conversion factor 833.33 and presented in Table 1.

The analysis of variance showed that the straw yield of maize differed significantly due to source of nitrogen. Application of nitrogen through Neem coated urea resulted in significantly highest straw yield per hectare over both remaining sources of nitrogen. Furthermore, the application of nitrogen through granular urea was also found more effective than prilled urea as during both the years and in pooled data analysis. The straw yield under S_3: neem coated urea was recorded 1.07, 0.55 and 0.81 per cent higher over the straw yield achieved under S_2: Granular urea and 5.22, 6.16 and 5.69 per cent higher over the yield achieved under S_1: Prilled urea during 2009, 2010 and in pooled data analysis respectively.

Straw yield was increased significantly with the increase in level of nitrogen attaining a maximum of 9370.43, 9354.82 and 9362.62 kg/ha under N_3: 100 kg N/ha during the years 2009, 2010 and in pooled data analysis respectively (Table 4.4.1). Which was found significantly superior over the yield under N_2: 75 kg N/ha during 2009 and in pooled data analysis but the differences were found non-significant in the year 2010.

Straw yield of maize differed significantly due to scheduling of nitrogen. The data pertaining to straw yield revealed that higher straw yield of 9392.23, 9366.22 and 9379.23 kg/ha was obtained under application of nitrogen in three splits, followed by 2 splits (9084.68, 9108.80 and 9096.74 kg/ha) and the lowest straw yield (8606.05, 8688.24 and 8647.15 kg/ha) was recorded in basal application during the years 2009, 2010 and pooled data analysis. The magnitude of straw yield increased under three splits application of nitrogen was 3.39, 2.83 and 3.11 per cent over 2 splits application and 9.14, 7.80 and 8.47 per cent and basal application, respectively for both the years and in pooled data analysis. However the difference between T_3: 3-splits applications (basal, 25 and 45 DAS) and T_2: 2-splits applications (basal and 25 DAS) were not found significant.

Economics of the treatments:

Cost of cultivation, gross return, net return and benefit cost ratio are best indicator of economic feasibility of any technology. All of these parameters were calculated under different treatments and presented below:

Cost of cultivation

Perusal of the data presented in Table 2 indicated that application of 100 kg N/ha through neem coated urea in three splits ($N_2T_3S_3$) registered highest cost of cultivation (Rs 16343, 17375 and 16859 per ha) followed by that is under application of 100 kg N/ha through prilled urea in three splits $N_3S_2T_3$ (Rs 16323, 17355 and 16839 per ha) and application of 100 kg N/ha through granular urea in three splits $N_3S_1T_3$ (Rs 16303, 17315 and 16809 per ha) during 2009, 2010 and pooled data analysis, respectively. The treatment combinations $N_1T_1S_1$ and $N_1S_2T_1$ were found to be associated with lowest cost of cultivation of Rs 15823, 16795 and 16309 per ha and Rs 15833, 16815 and 16324 under these treatment respectively during the 2009, 2010 and pooled data analysis.

As the sources of nitrogen are concerns, the highest cost of cultivation was noticed under S_3: neem coated urea followed by S_2: Granular urea during 2009, 2010 and in pooled data analysis. The lowest cost of cultivation was found under S_1: Prilled urea (Table 2).

Under various levels of nitrogen, the highest cost of cultivation was associated with N_3: 100 kg N/ha followed by N_2: 75 kg N/ha and the lowest was observed with N_1: 50 kg N/ha during both the years and in pooled data analysis (Table 2).

Under the schedules of nitrogen, the cost of cultivation was recorded highest under T_3: 3-splits applications (basal, 25 and 45 DAS) followed by T_2: 2-splits applications (basal and 25 DAS) and the lowest were observed under T_1: only basal application of nitrogen during both the years and in pooled data analysis (Table 2).

Table 2: Economics of the various sources, levels and scheduling of nitrogen

Treatment	Cost of cultivation (Rs/ha)			Gross return (Rs/ha)			Net return (Rs/ha)			B: C ratio		
	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
Source of nitrogen												
S_1: Prilled urea	16063	17055	16559	71940	87097	79518	55877	70042	62959	4.48	5.11	4.79
S_2: Granular urea	16078	17085	16582	75319	92623	83971	59241	75538	67389	4.68	5.42	5.05
S_3: NC urea	16093	17100	16597	75844	93025	84435	59751	75925	67838	4.71	5.44	5.07
SEm±	-	-	-	**1020**	**1362**	**1167**	**1020**	**1362**	**1167**	**0.06**	**0.08**	**0.07**
C.D. (at 5%)	-	-	-	**2895**	**3864**	**3313**	**2895**	**3864**	**3313**	**0.18**	**0.23**	**0.20**
Level of nitrogen												
N_1: 50 kg N/ha	15933	16922	16427	72212	87910	80061	56279	70988	63634	4.53	5.19	4.86
N_2: 75 kg N/ha	16078	17080	16579	73578	90428	82003	57500	73348	65424	4.58	5.29	4.93
N_3: 100 kg N/ha	16223	17238	16731	77312	94407	85860	61089	77169	69129	4.76	5.47	5.12
SEm±	-	-	-	**1020**	**1362**	**1167**	**1020**	**1362**	**1167**	**0.06**	**0.08**	**0.07**
C.D. (at 5%)	-	-	-	**2895**	**3864**	**3313**	**2895**	**3864**	**3313**	**0.18**	**0.23**	**0.20**
Scheduling of nitrogen												
T_1: Basal only	15978	16970	16474	71069	86981	79025	55091	70011	62551	4.45	5.13	4.79
T_2: 2-Splits	16078	17080	16579	74770	91937	83354	58692	74857	66775	4.65	5.38	5.02
T_3: 3-splits	16178	17190	16684	77263	93827	85545	61085	76637	68861	4.77	5.46	5.12
SEm±	-	-	-	**1020**	**1362**	**1167**	**1020**	**1362**	**1167**	**0.06**	**0.08**	**0.07**
C.D. (at 5%)	-	-	-	**2895**	**3864**	**3313**	**2895**	**3864**	**3313**	**0.18**	**0.23**	**0.20**

Table 3: Economics of the various treatment combinations

Treatment	Cost of cultivation (Rs/ha)			Gross return (Rs/ha)			Net return (Rs/ha)			B: C ratio		
	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
$N_1S_1T_1$	15823	16795	16309	65161	79001	72081	49338	62206	55772	4.12	4.70	4.41
$N_1S_1T_2$	15923	16905	16414	72892	87800	80346	56969	70895	63932	4.58	5.19	4.89
$N_1S_1T_3$	16023	17015	16519	76003	89580	82791	59980	72565	66272	4.74	5.26	5.00
$N_1S_2T_1$	15833	16815	16324	74606	92308	83457	58773	75493	67133	4.71	5.49	5.10
$N_1S_2T_2$	15933	16925	16429	74581	90963	82772	58648	74038	66343	4.68	5.37	5.03
$N_1S_2T_3$	16033	17035	16534	73296	90416	81856	57263	73381	65322	4.57	5.31	4.94
$N_1S_3T_1$	15843	16825	16334	66231	82899	74565	50388	66074	58231	4.18	4.93	4.55
$N_1S_3T_2$	15943	16935	16439	72841	89566	81204	56898	72631	64765	4.57	5.29	4.93
$N_1S_3T_3$	16043	17045	16544	74296	88657	81477	58253	71612	64933	4.63	5.20	4.92
$N_2S_1T_1$	15963	16945	16454	65201	82002	73601	49238	65057	57147	4.08	4.84	4.46
$N_2S_1T_2$	16063	17055	16559	69911	86328	78120	53848	69273	61561	4.35	5.06	4.71
$N_2S_1T_3$	16163	17165	16664	73470	90923	82196	57307	73758	65532	4.55	5.30	4.92
$N_2S_2T_1$	15978	16975	16477	70715	84981	77848	54737	68006	61371	4.43	5.01	4.72
$N_2S_2T_2$	16078	17085	16582	76703	94456	85579	60625	77371	68998	4.77	5.53	5.15
$N_2S_2T_3$	16178	17195	16687	74942	93957	84450	58764	76762	67763	4.63	5.46	5.05
$N_2S_3T_1$	15993	16990	16492	78536	98752	88644	62543	81762	72152	4.91	5.81	5.36
$N_2S_3T_2$	16093	17100	16597	77072	92584	84828	60979	75484	68231	4.79	5.41	5.10
$N_2S_3T_3$	16193	17210	16702	75656	89867	82761	59463	72657	66060	4.67	5.22	4.95
$N_3S_1T_1$	16103	17095	16599	71961	84246	78103	55858	67151	61504	4.47	4.93	4.70
$N_3S_1T_2$	16203	17205	16704	76013	94713	85363	59810	77508	68659	4.69	5.50	5.10
$N_3S_1T_3$	16303	17315	16809	76846	89279	83062	60543	71964	66253	4.71	5.16	4.93
$N_3S_2T_1$	16123	17135	16629	72956	90258	81607	56833	73123	64978	4.52	5.27	4.90
$N_3S_2T_2$	16223	17245	16734	73055	90963	82009	56832	73718	65275	4.50	5.27	4.89
$N_3S_2T_3$	16323	17355	16839	87016	105304	96160	70693	87949	79321	5.33	6.07	5.70
$N_3S_3T_1$	16143	17155	16649	74254	88380	81317	58111	71225	64668	4.60	5.15	4.88
$N_3S_3T_2$	16243	17265	16754	79865	100061	89963	63622	82796	73209	4.92	5.80	5.36
$N_3S_3T_3$	16343	17375	16859	83846	106461	95154	67503	89086	78295	5.13	6.13	5.63
SEm±	-	-	-	**3060**	**4084**	**3502**	**3060**	**4084**	**3502**	**0.19**	**0.24**	**0.21**
C.D. (at 5%)	-	-	-	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

4.6.2. Gross Return (Rs/ha)

The data on gross return are given in Table 2 and Table 3. The gross return was found highest under the treatment combinations $N_3S_2T_3$ (Rs 87016, 105304 and 96160 per ha) followed by $N_3S_3T_3$ (Rs 83846, 106461 and 95154 per ha) and $N_3S_2T_3$ (Rs 79865, 100061 and 89963 per ha) while the lowest cost of cultivation was associated with $N_1S_1T_1$ (65161, 79001 and 72081 per ha) and $N_2S_1T_1$ (65201, 82002 and 73601 per ha) during 2009, 2010 and pooled data analysis respectively.

The highest gross return under various sources of nitrogen was found to be associated with S_3: neem coated urea followed by S_2: Granular urea and the significantly lowest gross return were with S_1: Prilled urea in both the years and in pooled data analysis.

As the nitrogen levels are concerns, the highest gross return was recorded with N_3: 100 kg N/ha followed by N_2: 75 kg N/ha. The lowest gross return was recorded with N_1: 50 kg N/ha during both the years and in pooled data analysis.

In case of various schedules of nitrogen, the maximum gross return was recorded with T_3: 3-splits applications (basal, 25 and 45 DAS) followed by T_2: 2-splits applications (basal and 25 DAS) but did not differ statistically with each other during both the years and in pooled data analysis.

4.6.3. Net return (Rs/ha)

The data on net return are given in Table 2 and Table 3 and the analysis of variance is given in Appendix XVIII. The net return was found highest under the treatment combinations $N_3S_2T_3$ (Rs 70693, 87949 and 79321 per ha) followed by $N_3S_3T_3$ (Rs 67506, 89086 and 78295 per ha) and $N_3S_2T_3$ (Rs 63622, 82796 and

73209 per ha) while the lowest cost of cultivation was associated with $N_1S_1T_1$ (49338, 62206 and 55772 per ha) and $N_2S_1T_1$ (49238, 65057 and 57147 per ha) during 2009, 2010 and pooled data analysis respectively.

The highest net return under various sources of nitrogen was found to be associated with S_3: neem coated urea followed by S_2: Granular urea and the significantly lowest net return were with S_1: Prilled urea in both the years and in pooled data analysis.

As the nitrogen levels are concerns, the highest net return was recorded with N_3: 100 kg N/ha followed by N_2: 75 kg N/ha while it was noticed with N_1: 50 kg N/ha during both the year and in pooled data analysis.
In case of various schedules of nitrogen, the maximum net return was recorded with T_3: 3-splits applications (basal, 25 and 45 DAS) followed by T_2: 2-splits applications (basal and 25 DAS) but did not differ statistically with each other during both the years and in pooled data analysis.

4.6.4. Benefit: cost ratio

The data on B: C ratios are given in Table 2 and Table 3. The B: C ratios of 5.33, 6.07 and 5.7 were found highest under the treatment combinations $N_3S_2T_3$ followed by $N_3S_3T_3$ (5.13, 6.13 and 5.63) during 2009, 2010 and in pooled data analysis. The treatment combination came after these was $N_3S_3T_2$ in 2009 and in $N_2S_3T_1$ in 2010. The lowest B: C ratio was associated with $N_1S_1T_1$ (4.12, 4.70 and 4.41) and $N_2S_1T_1$ (4.08, 4.84 and 4.46) during 2009, 2010 and pooled data analysis respectively.

The highest B: C ratio under various sources of nitrogen was found to be associated with S_3: neem coated urea followed by S_2: Granular urea but it was not differed statistically and the significantly lowest B: C ratio was registered with S_1: Prilled urea in both the years and in pooled data analysis.

As the nitrogen levels are concerns, the highest B: C ratio was noticed with N_3: 100 kg N/ha followed by N_2: 75 kg N/ha. The lowest B: C ratio was recorded with N_1: 50 kg N/ha during both the years and in pooled data analysis.

In case of various schedules of nitrogen, the maximum B: C ratio was recorded with T_3: 3-splits applications (basal, 25 and 45 DAS) followed by T_2: 2-splits applications (basal and 25 DAS) but did not differ statistically with each other during both the years and in pooled data analysis.

IV. Conclusion

On the basis of the two years experimentation, it can be concluded that for achieving the higher growth and yields with better monetary returns from maize variety JM-216 in the Malwa region of Madhya Pradesh nitrogen may be applied through Neem coated urea @ 100 kg/ha in 3 splits doses i.e. basal, 25 and 45 DAS. This application was found more productive and profitable.

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