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Effect of Plant Density and Nitrogen Levels on Productivity and Economics of Rice Fallow Maize (*Zea mays*.L) under Zero Tillage Conditions

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ABSTRACT

A field experiment was conducted on clay loam soils of Agricultural College Farm, Bapatla during *rabi* 2009-10 and 2010-11 on maize under rice fallows. The treatments consisted of three planting densities (67000, 80000 and 100000 plants ha^{-1}) as main plots and four levels of nitrogen (120, 180, 240 and 300 kg N ha^{-1}) and were allotted to sub-plots. The experiment was laid in split-plot design and the treatments were replicated thrice. Plant growth parameters like plant height, dry matter accumulation, chlorophyll (SPAD readings) significantly influenced by both plant densities and levels of N application. Plant height and dry matter accumulation were significantly higher with 100000 plants ha^{-1} than 67000 plants ha^{-1} but was on a par with 80000 plants ha^{-1}. However, chlorophyll content, days to 50% tasseling and 50% silking were significantly higher at low planting density (67000 plants ha^{-1}) than higher planting densities of 80000 and 100000 plants ha^{-1}. Yield attributes (cob length, number of kernels cob^{-1}, kernel weight cob^{-1}, and shelling percentage) were significantly higher at lower planting density but kernel (79.3 and 81.7 q ha^{-1}) and stover yields (101.1 and 100.4 q ha^{-1}) were significantly higher at 100000 plants ha^{-1} than that recorded with 67000 plants ha^{-1} but was comparable with 80000 plants ha^{-1}. Harvest index was also higher with lower planting density of 67000 plants ha^{-1}(46.0 and 46.1%) than that recorded with higher level of planting density (100000 plants ha^{-1}) (43.9 and 44.8%). Nutrient uptake was significantly superior with higher level of planting density but soil fertility status reduced with increase in planting density from 67000 to 100000 plants ha^{-1}. Application of N significantly increased plant height, dry matter accumulation, chlorophyll content, yield attributes, yields net returns during both the years. The maximum kernel yield was recorded with application of 300 kg N ha^{-1} (81.3 and 85.3 q ha-1) but was on par with 240 kg Nha^{-1} (77.5 and 79.0 q ha^{-1}). HI increased with increase in level of N from 120 (43.5 and 44.0%) to 300 kg N ha^{-1} (46.4 and 46.7%). Net returns and benefit cost ratio (BCR) higher with higher planting density in combination with 300kg N ha^{-1}.

Key words : Chlorophyll (SPAD readings), Nutrient uptake, Soil fertility status, Zero tillage.

Maize (*Zea mays* L.) is one of the most important cereals of the world after rice and wheat. Among several management practices that influence crop productivity, fertilizer application and plant density are of paramount importance for its role in growth and development of the crop. In recent years, rice - maize sequence is gaining popular in place of rice - blackgram in the Krishna and Godavari agro-climatic zones of Andhra Pradesh due to late release of canal water and severe weed and disease problems in rice - fallow blackgram. Maize has become a crop of interest in rice fallows among the farmers of coastal region of A.P., because of poor yields of pulses, increased pest and diseases, weed menace and less remunerative prices. Rice fallow maize under zero-tillage is practiced by farmers for multipurpose *viz*; grain, dairy, poultry, and vegetable farmers and accepted as a beneficial cropping system. Growers adopt this system to increase their efficiency and profitability, and to improve their environmental stewardship. Potentiality of maize crop for its growth and development can be fully exploited by adopting suitable agronomic practices such as optimum spacing, fertilizers *etc*. particularly N. The farmers of this region are using huge quantities of inorganic commercial fertilizers untimely and indiscriminately to get better yields in maize under rice fallow situations. Continuous use of inorganic sources of N leads to decline or stagnation in productivity due to limitation of one or more nutrients. Indiscriminate use of chemical fertilizers and agro-chemicals rendered the arable soils unproductive as a consequence of unfavourable

Table 1. Growth parameters of maize under rice fallows as influenced by planting density and level of N application during *rabi* 2009-10 and 2010-11.

Treatments	Plant height(cm) at maturity			Days to 50% tasseling (Days)			Days to 50% silking (Days)			Chlorophyll (SPAD readings) at 60DAS		
	2009-10	2010-11	Mean	2009-10	2010-11	Mean	2009-10	2010-11	Mean	2009-10	2010-11	Mean
Plant density (plants ha^{-1})												
D_1-67000(60 cm x 25 cm)	243	260	252	57.8	57.3	57.6	68.2	66.9	67.6	46.8	51.6	49.2
D_2- 80000 (50 cm x 25 cm)	260	280	270	60.5	60.2	60.4	71.9	70.3	71.1	45.3	50.1	47.7
D_3 -100000(40 cm x 25 cm)	272	291	282	63.5	62.3	62.9	73.6	72.9	73.3	43.8	49.3	46.6
SEm±	4.2	4.0		1.1	0.9		0.8	0.9		0.5	0.3	
CD(0.05)	17	16		4.2	3.7		3.1	3.4		2.1	1.3	
CV (%)	5.7	5.0		6.1	5.4		3.8	4.3		4.1	2.2	
N levels($kgha^{-1}$)												
N_1- 120	245	263	254	63.5	62.0	62.8	73.3	72.0	72.7	41.9	46.9	44.4
N_2- 180	254	275	265	61.4	60.9	61.2	72.2	70.7	71.5	44.3	48.8	46.6
N_3- 240	263	281	272	59.5	59.3	59.4	70.4	69.5	70.0	46.6	52.4	49.5
N_4- 300	271	290	281	58.0	57.4	57.7	68.9	67.9	68.4	48.5	53.5	51.0
SEm±	3.6	4.4		1.2	1.1		0.8	1.0		0.8	0.7	
CD(0.05)	11	13		3.7	3.2		2.5	2.8		2.5	2.0	
CV (%)	4.2	4.7		6.1	5.3		3.5	4.1		5.6	4.0	
Interaction(PDXN)	NS	NS		NS	NS		NS	NS		NS	NS	

SPAD : Single photon avalanche diode

physical, chemical and biological characteristics of soil. The production technology for zero-tillage maize in respect of plant density and fertilizer rates, particularly nitrogen is not available. In order to avoid the excess use of nitrogenous fertilizers and to maintain the system sustainable productivity, the present investigation is carried out.

MATERIAL AND METHODS

A field experiment was conducted for two consecutive years (2009-2010 and 2010-2011) at Agricultural College farm, Bapatla on sandy clay loam soil with pH 8.0, OC 0.3%, available N (192 kg ha^{-1}), available P_2O_5 (37 kg ha^{-1}) and available K_2O (740 kg ha^{-1}). The experiment was laid in split-plot design and the treatments were replicated thrice. There are 12 treatment combinations in the study and the treatment combinations comprised three planting densities (D) and four nitrogen levels (N); *viz*., D_1: 67000 (60 cm x 25 cm) plants ha^{-1}; D_2: 80000 (50 cm x 25 cm) plants ha^{-1} and D_3: 100000 (40 cm x 25 cm) plants ha^{-1} allotted to main plots and four levels of nitrogen viz. N_1: 120; N_2: 180: N_3: 240 & N_4: 300 kg ha^{-1}) as sub plot treatments. The fertilizers of P (60 kg P_2O_5 ha^{-1}) and K (40 kg K_2O ha^{-1}) were applied through single superphosphate (SSP) and murate of potash (MOP) as basal at the time of sowing. Maize hybrid "Pioneer 30V 92" was sown on 04-01-2010 and 08-1-2011 under zero tillage conditions and harvested on 19-4-2010 and 23-4-2011during first and second year respectively. A total of 14.1 and 137.5 mm rainfall was received during the study period of both the years.

Maize was sown under zero tillage conditions immediately after harvest of *kharif* rice by dibbling two seeds per hill with the help of pointed bamboo peg and marked nylon ropes as per the treatments. Thinning and gap filling was done at 10 DAS by keeping one seedling $hill^{-1}$. Required

Table 2. Dry matter accumulation and yield attributes of maize under rice fallows as influenced by planting density and level of N application during *rabi* 2009-2010 and 2010-11.

Treatments	Dry matter accumulation at maturity (q ha^{-1})			Cob length (cm)			No. of kernels cob^{-1}			Kernel weight cob^{-1}(g)		
	2009-10	2010-11	Mean	2009-10	2010-11	Mean	2009-10	2010-11	Mean	2009-10	2010-11	Mean
Plant density (plants ha^{-1})												
D_1-67000 (60 cm x 25 cm)	136.0	166.8	151.4	19.2	20.2	19.7	559	579	569	185	216	201
D_2- 80000 (50 cm x 25 cm)	158.0	183.9	165.1	17.6	18.6	18.1	491	500	496	160	200	180
D_3 -100000 (40 cm x 25 cm)	169.7	194.7	181.1	16.1	17.6	16.9	435	438	437	141	188	165
SEm±	4.9	3.1		0.3	0.3		18.7	13.4		4.1	3.9	
CD(0.05)	19.4	12.3		1.2	1.3		74	53		16	15	
CV (%)	11.0	6.0		6.1	6.2		13.1	9.2		8.8	6.7	
N levels(kgha^{-1})												
N_1- 120	130.4	163.7	145.0	15.8	17.1	16.5	418	413	416	128	178	153
N_2- 180	147.2	174.6	158.5	17.4	18.5	18.0	471	486	479	141	195	168
N_3- 240	161.4	189.2	172.7	18.2	19.6	18.9	521	531	526	153	208	181
N_4- 300	179.3	199.7	187.3	19.1	20.1	19.6	570	592	581	168	224	196
SEm±	3.1	3.8		0.6	0.4		10.0	15.4		5.1	4.4	
CD(0.05)	9.2	11.2		1.6	1.2		30.0	46		15	13	
CV (%)	6.0	6.2		9.4	6.2		6.1	9.2		9.4	6.5	
Interaction(PDXN)	NS	NS		NS	NS		NS	NS		NS	NS	

quantity of N, P and K was applied through urea (46% N), single super phosphate (SSP) (16% P_2O_5) and murate of potash (MOP) (60% K_2O), respectively, as per the treatments. Nitrogen applied in three splits *i.e.* at basal, 25 and 55 DAS. The crop was maintained by adopting the recommended package of practices. A total of three light irrigations were given immediately after application of fertilizers. Pre-emergence application of weedicides like Paraquat @10 ml L^{-1} and Atrazine @5 g L^{-1} were applied on second day after sowing of maize for prevention of regrowth of paddy stubbles and to control germinating weeds. Chlorophyll was measured by using chlorophyll meter (Minolta-502 plus) and recorded the SPAD readings. Need based plant protection measures were taken up during crop growth period. The data on plant height, dry matter accumulation, yield attributes and yield were recorded in two years and analysed as per standard statistical procedures described by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Growth parameters

The results on growth parameters *viz*., plant height, dry matter accumulation, 50 per cent tasseling , 50 per cent silking and chlorophyll (SPAD readings) were significantly (Table 1&2) influenced by both planting density and levels of nitrogen during both the years of investigation. Plant height and dry matter accumulation at 30, 60 DAS and at maturity were significantly higher with 80000 plants ha^{-1} than 67000 plants ha^{-1} and on a par with 100000 plants ha^{-1}. Closely spaced plants elongated more rapidly, their rate of dry weight gain was less than that of wider spaced plants which might be the reason for more plant height at higher density in combination with availability of more nutrients. Further, more competition for light and higher intra row competition for nutrient and moisture due to over-crowding of plants might be the probable reasons for increased plant height under high planting densities. These results are in agreement with those of Massey and Guar (2006) and Suryavanshi *et al.* (2008).

Table 3. Yield components and yield of maize under rice fallows as influenced by planting density and level of N application during *rabi* 2009-10 and 2010-11

Treatments	Shelling percentage			Test weight (g)			Kernel yield (q ha^{-1})			Stover yield (q ha^{-1})			HI (%)		
Plant density (plants ha^{-1})	2009-10	2010-11	Mean	2009-10	2010-11	Mean	2009-10	2010-11	Mean	2009-10	2010-11	Mean	2009-10	2010-11	Mean
D_1-67000 (60 cm x 25 cm)	77.6	75.1	76.4	29.5	31.4	30.5	65.8	68.0	66.9	75.7	79.8	77.8	46.0	46.1	46.1
D_2- 80000(50 cm x 25 cm)	74.0	72.8	73.4	27.1	28.6	27.9	73.0	76.8	74.9	92.9	92.5	92.7	44.3	45.4	44.9
D_3 -100000 (40 cm x 25cm)	70.4	70.8	70.6	25.1	27.0	26.1	78.7	81.7	80.2	101.2	100.4	100.8	43.9	44.8	44.4
SEm±	0.7	0.4		0.4	0.4		1.8	1.7		2.5	2.7		0.4	0.3	
CD(0.05)	2.6	1.7		1.5	1.5		7.1	6.8		9.8	10.6		1.6	NS	
CV (%)	3.0	2.1		5.0	4.6		8.6	7.9		9.6	10.3		3.1	2.3	
N levels(kgha^{-1})															
N_1- 120	70.8	70.8	70.8	25.4	27.1	26.3	61.5	64.3	62.9	79.6	81.9	80.8	43.5	44.0	43.8
N_2- 180	73.4	72.3	72.9	26.8	28.2	27.5	69.6	73.4	71.5	88.0	89.7	88.9	44.0	45.1	44.6
N_3- 240	74.6	73.3	74.0	27.8	29.3	28.6	77.5	79.0	78.4	93.9	93.6	93.8	45.0	45.9	45.5
N_4- 300	77.2	75.3	76.3	28.9	31.5	30.2	81.3	85.3	83.3	98.2	98.4	98.3	46.4	46.7	46.6
SEm±	0.7	0.7		0.7	0.9		2.4	2.4		3.1	3.8		0.4	0.6	
CD(0.05)	2.0	2.0		2.1	2.5		7.1	7.1		9.1	11.3		1.1	1.8	
CV (%)	2.8	2.8		7.9	8.8		9.8	9.5		10.2	12.5		2.5	4.0	

Similarly, dry matter accumulation increased with increase in plant density which could be attributed due to more number of plants per unit area compensating for the reduction in dry weight plant^{-1} at higher level of planting density. The findings are in close accordance with the results of Gaur *et al.,* (1992). However, number of days taken to reach 50 per cent tasseling and 50 per cent silking was significantly less with lower planting density (67000 plants ha^{-1}) compared to that with higher planting densities. More competition between plants for different resources particularly for moisture and nutrients at higher planting densities might have slowed down the physiological development that ultimately delayed the emergence of tassels and extrusion of silks. The findings are in agreement with those of Shanthi *et al.* (1997) and Mercy (2011). The chlorophyll content recorded was more at lower planting density (67000 plants ha^{-1}) than that with higher planting density (100000 plants ha^{-1}). The reduction in chlorophyll (SPAD readings) at higher planting density might be due to severe competition between the plants for effective photosynthetically active radiation and resulted in lower production of chlorophyll through photosynthesis. Similar results were also reported by Mali and Singh (1989). All the above growth parameters (plant height, dry matter accumulation, and chlorophyll) increased with each increment of nitrogen, as nitrogen is one of the essential nutrient for growth and development of plant. Being constitute of chlorophyll increased photosynthetic efficiency of crop resulted in higher growth and development. These results are in close conformity with those of Suryavanshi *et al.* (2008) and Bharathi (2010).

Yield attributes and yield

Kernel yield and stover yield were significantly influenced by planting densities and levels of N given to maize. Irrespective of N levels given to maize, growth parameters like plant height and dry matter accumulation were higher at higher level of planting density, while yield attributes (cob length, number of kernels cob^{-1}, kernel weight cob^{-1}, shelling percentage and test weight) were reduced with increase in planting densities from 67000 to 100000 plants ha^{-1} (Table 2). This might be due to lower plant population in wider spacing which received sufficient space, moisture, and nutrients and production of more photosynthates per unit area, beneficial for growth and development of maize

Table 4. Nutrient uptake of maize at maturity under rice fallows as influenced by planting density and N levels during *rabi* 2009-10 and 2010-11.

Treatments	Nutrient uptake (kg ha^{-1}) N			P			K			BCR		
Plant density (plants ha^{-1})	2009-10	2010-11	Mean	2009-10	2010-11	Mean	2009-10	2010-11	Mean	2009-10	2010-11	Mean
D_1-67000 (60 cm x 25 cm)	109.8	136.3	123.1	33.0	36.2	34.6	114.7	133.0	123.9	1.46	2.09	1.78
D_2- 80000 (50 cm x 25 cm)	133.6	162.6	148.1	41.6	43.9	42.8	137.5	147.0	142.3	1.61	2.33	1.97
D_3-100000 (40 cm x 25 cm)	150.4	176.0	163.2	46.1	48.4	47.3	152.7	163.4	158.1	1.75	2.46	2.11
SEm±	3.3	1.1		0.8	0.7		2.1	1.5				
CD(0.05)	12.8	3.9		3.1	2.8		8.3	5.8				
CV (%)	8.6	2.2		6.8	5.8		5.4	3.6				
N levels(kgha^{-1})												
N_1- 120	108.8	136.2	122.5	32.1	36.3	34.2	111.4	126.7	119.1	1.33	1.96	1.65
N_2- 180	122.3	149.7	136.0	37.5	39.7	38.6	126.9	142.1	134.5	1.55	2.26	1.91
N_3- 240	137.1	164.1	150.6	43.4	45.8	44.6	141.8	153.8	147.8	1.75	2.40	2.10
N_4- 300	156.8	183.1	170.0	47.9	49.6	48.8	159.8	168.6	164.2	1.79	2.55	2.17
SEm±	2.8	3.6		0.9	0.6		2.7	2.7				
CD(0.05)	8.4	10.8		2.6	1.8		8.0	7.9				
CV (%)	6.4	6.9		6.4	4.2		6.0	5.4				
Interaction(PDXN)	NS	NS		NS	NS		NS	NS				

crop as compared to closer spacing. These findings are in conformity with those of Thakur (1997) and Vishalu *et al*. (2009). The maximum kernel yield of 78.7 and 81.7 q ha^{-1} was recorded at higher planting density of 100000 plants ha^{-1} during first and second year, respectively, however, it did not reach the level of significance with 80000 plants ha^{-1} (73.0 and 76.8q ha^{-1}). Significantly higher kernel and stover yields were recorded with higher planting density might be due to beneficial effect of spacing, moisture, nutrients and other growth promoting factors on wide spaced plants having lower plant population. Similar trend of results was also reported by Bangarwa *et al.* (1989) and Misra *et al.* (1994). The nutrient uptake by maize at maturity was recorded more at higher planting density (100000 plants ha^{-1}) compared to that of lower planting density (67000 plants ha^{-1}) (Massey and Gaur, 2006).

Irrespective of planting densities, plant growth parameters (plant height, dry matter accumulation, chlorophyll (SPAD readings), yield components (cob length, kernel weight cob^{-1}, number of kernels cob^{-1}, shelling percentage and test weight), yield and nutrient uptake were increased with increase in level of N application from 120 to 300 kg N ha^{-1} (Table 1,2,3 &4). Adequate supply of N might have helped the maize plants to increase their growth which in turn put forth more photosynthetic surface and chlorophyll content, thus contributing for more dry matter accumulation. Similar result was reported earlier by Singh and Singh (2006). The highest kernel yield (81.3 and 85.3 q ha^{-1}) was observed with 300 kg N ha^{-1}, respectively (Table 3). The difference between 120,180 and 240 kg N ha^{-1} was found significant in first year while, in second year, the difference between 120 and 180 kg N ha^{-1} was only significant but comparable between 180 and 240 likewise with 240 and 300 kg N ha^{-1}. The progressive increase in kernel yield showed linear response to the application of nitrogen from 120 to 300 kg ha^{-1}, irrespective of planting densities (Fig 1 & 2). The positive response to higher level of nitrogen on kernel yield could be ascribed to overall improvement in growth which enabled the plant to absorb more

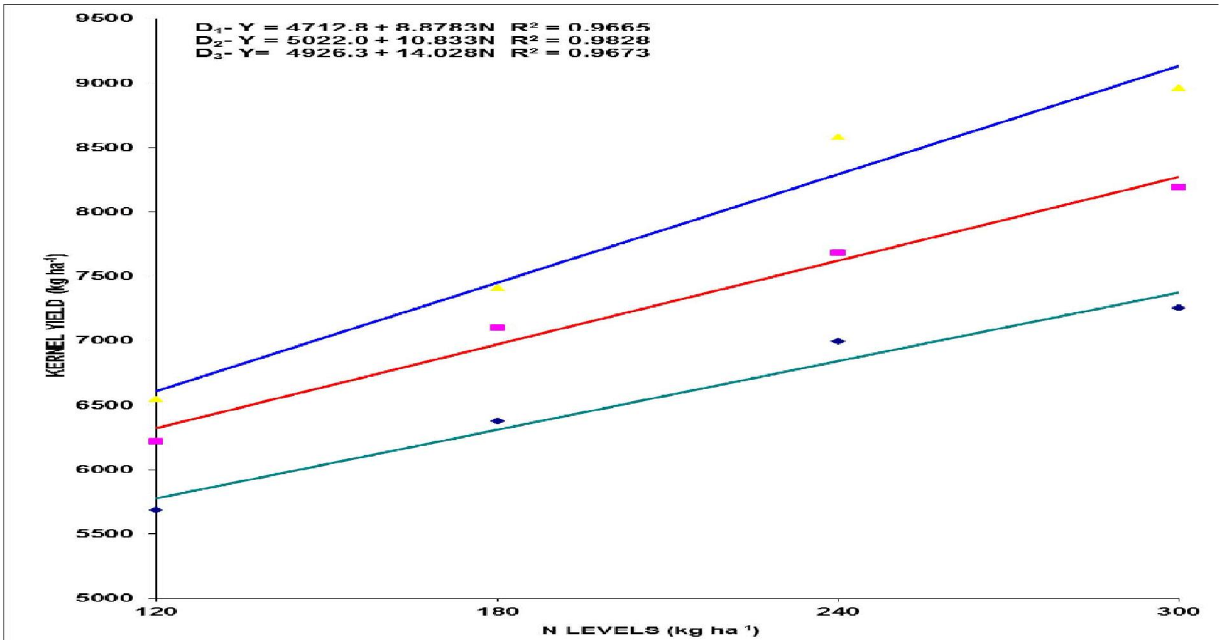

Fig. 1: Rice fallow maize response to N levels under zero tillage during 2009-10

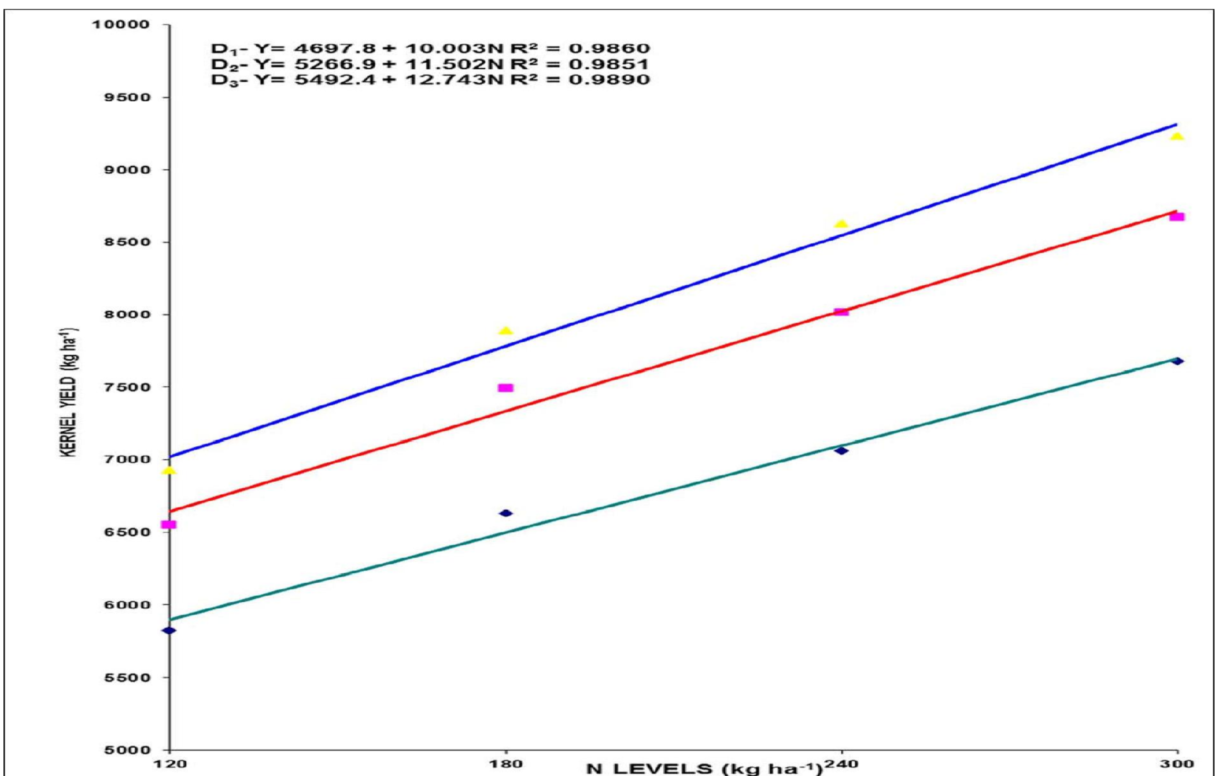

Fig.2: Rice fallow maize response to N levels under zero tillage during 2010-11

quantity of photosynthates accumulating them in sink. These results are in concordance with the findings of Nimje and Seth (1988) and Lakshmi (2010).

The highest BCR (1.75 and 2.46 in first and second year of study) was recorded at the highest level of planting density (100000 plants ha^{-1}) with application of 300 kg N ha^{-1} followed by 240 kg N ha^{-1} due to higher kernel yields (Table 4). The lowest net returns and BCR were recorded with application of 120 kg N ha^{-1} might be because of higher cost of cultivation. These results are in confirmation with the findings of Sachan and Gangawar (1996).

From the investigations conducted for two consecutive years, it was clearly evident that adoption of higher level of planting density (80000 plants ha^{-1}) with application of 240 kg N ha^{-1} under zero tillage conditions was found to be optimum for getting higher yields.

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