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Growth and Yield of Maize- Rajmash Cropping Sequence Affected by Different Agronomic Practices

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ABSTRACT

A field experiment was conducted during the *kharif* and *rabi* seasons for two consecutive years 2008-09 and 2009-10 to evaluate effect of Agronomic Practices on growth and yield under Maize-Rajmash Cropping Sequence on sandy clay loam at Agricultural College Farm, Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad, Andhra Pradesh. The treatment variables were three green leaf manuring options viz. no green leaf manure, dhaincha green leaf manuring @ 10 t ha^{-1}, sunhempgreenleafmanuring @ 10 t ha^{-1}, two irrigation levels viz. Rainfed conditions. Irrigation at 1.0 IW/CPE ratio to maize and 0.8 IW/CPE ratio and 1.0 IW/CPE ratio to rajmash and four fertility levels viz. F_1 – 120:60:40 / 40:60:30 kg NPK ha^{-1}F_2 – 120:00:40 / 40:00:30 kg NPK ha^{-1}, F_3 – 180:00:40 / 60:00:30 kg NPK ha^{-1} and F_4 – 240:00:40 / 80:00:30 kg NPK ha^{-1} to maize and rajmash, respectively.In maize, greenleaf manuring with dhaincha andsunhemp @ 10 t ha^{-1} and scheduling irrigation at 1.0 IW/CPE ratio significantly increased growth parameters at harvest, grain yield as compared to no green leaf manuring and rainfed maize treatment. Among fertility levels, 240:00:40 kg NPK ha^{-1} (F_4) produced significantly taller plants with higher leaf area index and drymatter production and as well as the grain andstover yield but it was on par with fertility level of 180:00:40 kg NPK ha^{-1}(F_3)in both years. In rajmash, greenleafmanuring with dhaincha and scheduling irrigation at 1.0 IW/CPE ratio significantly influenced the growth parameters. Seed and haulm yield as compared to no greenleafmanuring and 0.8 IW/CPE ratio treatments in both the years. Among the fertility levels, 80:00:30 NPK kg ha^{-1} (F_4) resulted in numerically higher growth and yield but it was on par with fertility level on 40:60:30 kg NPK kg ha^{-1}(F_1).

Keywords : *Agronomic Practices, Green Manuring, Irrigation, Maize, Nutrient Management and Rajamsh.*

Maize is the most important cereal crop next to wheat and rice in the world. Maize has high production potential compared to any other cereal crop. Globally it occupies an area of 158.03 million hectares, with a production of 791.7 MTand average productivity of 5010 kg ha^{1} (FAOSTAT, 2008). In India, maize is cultivated in an area of 8.17 million ha with a production of 19.73 million tones and average productivity of 2415 kg ha^{1} (Indiastat.com,2010). Recently there has been tremendous increase in area, production and productivity of maize in Andhra Pradesh.

The productivity of maize largely depends on its nutrient management. Maize being an exhaustive crop, demands heavy dose of fertilize application and it is the key factor in augmenting the production. (Ghosh and Singh 1996).

The positive role of green manuring in crop production has been known since ancient time. Importance of this soil amelioration practice is increasing in recent years because of high cost of chemical fertilizers, increased risk of environmental pollution, and a need for sustainable cropping systems. Green manuring can improve soil physical, chemical and biological properties and consequently crop yields. In addition, green manure crops generally accumulate large amount of P and on decomposition of residues of these crops can provide a larger pool of mineralizable soil organic P for succeeding crops (Tissen *et al*., 1994).

Rajmash is anunexploited pulse crop in A.P. Rajmash can be a suitable sequence component crop in maize based cropping system which demands higher doses of plant nutrients. The success of the system solely depends on its ability to tap the unexploited nutrient reserves in the soil and thereby reducing cost of cultivation. The per capita availability of pulses has decreased from 60.7 g in 1951 to 35.5 g in 2007. There is a need to increase pulse production. Keeping this in view, to explore the avenues for enhancing the availability of phosphorus in high P containing soils, the present investigation was conducted.

MATERIAL AND METHODS

The present experiment was conducted at the College Farm, College of Agriculture, Rajendranagar, Hyderabad, The farm is geographically situated at an altitude of 542.6 m above mean sea level at 17^{0}19' N latitude at78^{0} 23' E longitude. The total rainfall received during Kharif 2008 and 2009 was 764.5 mm and 481.3 mm in 24 and 26 rainy days, respectively. During *rabi* seasons of 2008-09 and 2009-10, 10.4 mm and 38.2 mm rainfall was received in one and three rainy days, respectively. The soil of the experimental field was sandy clay loam with medium organic carbon content, low in available nitrogen, high in available phosphorus and potassium. The experiment was laid out in a split –

plot design comprising six main plot treatments and four sub-plot treatments, replicated thrice. The treatment variables were three green leaf manuring options viz. no green leaf manure, dhaincha green leaf manuring @ 10 t ha $^{-1}$, sunhemp green leaf manuring @ 10 t ha^{-1}, two irrigation on levels vi. Rainfed conditions, irrigation at 1.0 IW/CPE ratio to maize and 0.8 IW/CPE ration and 1.0 IW/CPE ration to rajmash and four fertility levels viz. F_1– 120:60:40 / 40:60:30 kg NPK ha^{-1}, F_2- 120:00:40 / 40:00:30 kg NPK ha^{-1}, F_3- 180:00:40 / 60:00:30 kg NPK ha^{-1} and F_4- 240:00:40 / 80:00:30 kg NPK ha^{-1} to maize and rajmash, respectively. About 300 mm of irrigation water applied in six irrigations which coincided with the physiological demands of maize crop and environmental needs of the crops because the irrigations were scheduled based on ET needs of crop during long dry spells. As per the irrigation scheduling at 0.8 and 1.0 IW/CPE ratio, 350 and 450 mm of water was applied in seven and nine irrigations in first year and 350 and 400 mm in seven and eight irrigations in second year, respectively for rajmash crop. Dhaincha and Sunhemp were raised in separate field as pre-monsoon crop each during May for kharif and as pre-rabi crop in October for *rabi* in both the years.

RESULTS AND DISCUSSION

1. Effect of GLM on growth attributes and yield.

a. Maize

The growth of maize, in terms of plant height at harvest were substantially maximum with dhaincha and sunhemp GLM @ 10 t ha^{-1} treatments as compared to no green leaf manuring during both the years of study (Table-1). Increase in plant height due to dhaincha and sunhemp GLM might be due to primarily, enrichment of soil nutrients while secondarily due to maintenance of better physico-chemical and biological properties of the soil. The reports of Nagaraj et al (2004), Prasanna Kumar (2007) and Sujatha *et al.,* (2008) corroborate with the findings of the study. But the same kind of trend was not observed in the case of leaves.

Similarly, dry matter production was found to be higher at harvest (Table-1) with green leaf manuring of dhaincha and sunhemp GLM @ 10 t ha^{-1} treatments as compared to no green leaf throughout the crop growth period resulting in-enhanced carbohydrate synthesis, which ultimately led to higher dry matter accumulation (Table-1). The results corroborate with the findings of Nagaraj *et al.,* (2004).

Grain and stover yield of maize were significantly influenced by green leaf manuring (Table-2). Dhaincha green manuring (5249 kg ha^{-1} mean of two years) and sunhemp GLM (5172 kg ha^{-1} mean of two years) gave significantly higher mean grain yield over no green leaf manuring (4280 kg ha^{-1} mean of two years). Dhaincha (8699 kg ha^{-1}) and sunhemp (8589 kg ha^{-1}) green leaf manuring treatments recorded significantly higher mean stover yield (Table-2) during both years of study over no green leaf manuring (7137 kg ha^{-1}). Dhaincha and sunhemp green leaf manuring gave 22.6 per cent and 21.8 per cent more grain yield of maize (mean of two years) over no green manuring respectively. Prasanna Kumar (2007), Sujatha *et al* (2008), Channabasavanna *et al* (2008) reported the same kind of results.

b. Rajmash

Plant height of rajmash was significantly influenced by green leaf manuring at harvest of crop during both the years of investigation. Highest plant heightwas observed with dhaincha and sunhemp green manuring during both the years. Increase in plant height with dhaincha and sunhemp GLM might be due to primarily, enrichment of nutrients in soil while secondarily due to release of native P and maintenance of better physic-chemical and biological properties of the soil. Increased plant height with application of 10 t ha^{-1} FYM was reported by Singh and Verma (2002).

Highest leaf area index was observed with dhaincha and sunhemp green leaf manuring, while lowest with no green leaf manuring. Dhaincha green leaf manuring produced 5.6 and 7.8 per cent increase in LAI than no green leaf manuring treatment in first and second year respectively. In dry matter production same kind of trend is reported that of plant height and leaves. This might be attributed to increased plant height and leaf area maintained throughout the crop growth periods resulting in enhanced carbohydrate synthesis, which ultimately led to higher dry matter accumulation. Kumar and Puri (2002) also reported same kind of results.

Seed and haulm yield of rajmash was significantly influenced by green leaf manuring during both the years of study where dhaincha and sunhemp green leaf manuring recorded highest seed and haulm yield, while lowest with no green leaf manuring during both years of study. Dhaincha and sunhemp green manuring recorded 26.6 and 23.5 per cent increase in seed yield (main of two years) over no green manuring, where as in haulm Dhaincha and sunhemp recorded 26.9 and 24.9 per cent more yield contributing characters might have contributed for increase seed and saulm yield with Dhaincha and sunhemp green leaf manuring. Better plant height and leaf area could have resulted in better interception and utilization of solar energy leading to better photosynthetic rate and resulting in better dry matter accumulation which results in enhanced haulm yield. These results corroborate with the findings of Singh and Verma (2002) and Datt *et al.,* (2006).

2. Effect of Irrigation Scheduling of growth attributed and yield

a. Maize

Increase in plant height with irrigation scheduling at IW/CPE ratio of 1.0 was due to optimum soil moisture availability to the crop during crucial crop growth stages and alsofavoured better nutrient uptake, cell division and cell enlargement. But the leaf number was not influenced at any crop growth stages due to irrigation scheduling in both the years, but resulted higher leaf area index. Similar findings were revealed by Sundar Singh (2001) and Bharati *et al.,* (2007) who state that irrigated crop benefited with higher leaf area index over rainfed crop.

Dry matter production was found to be superior at harvest with irrigation scheduled at IW/CPE ratio of 1.0 compared to rainfed conditions during both the years. The increased plant height and more leaf area index recorded with irrigation treatment have increased dry matter at harvest. These results corroborate with the findings of Sundar Singh (2001) and Hussaini *et al.,* (2001).

Scheduling of irrigation at 1.0 IW/CPE ratio recorded 20.1 and 15.6 per cent 16.4 and 13.6 cent increase in grain and stover yield during first and second year, respectively over rainfed condition. The grain yield obtained under rainfed condition was distinctly lower than that of irrigated conditions. This could, probably be due to inadequate water supply during peak periods of water demand of the crop growth, unlike the irrigated crop which received sufficient water supply in consonance with physical demands, especially during long dry spells and shown favourable influence on crop growth and development and final yield attributes. All these favored high maize yields with irrigation. These results of present study are in conformity with the findings of Sridhar *et al.,* (1991), Jadhav *et al.,* (1992) and Hussaini, *et al.,* (2002).

b. Rajmash

Scheduling of irrigation at IW/CPE ratio of 1.0 had a favourable influence on growth and yield of rajmash as compared to irrigation at 0.8 IW/CPE ratio during both the years of study.

Plant height of rajmash differed significantly with different irrigation levels at harvest of crop. Scheduling of irrigation at 1.0 IW/CPE recorded highest plant height at 50, 75 DAE and at harvest, while it was lower with scheduling of irrigation at 0.8 IW/CPE during both the years of study. This might be due to optimum soil moisture availability favoring root nodule formation which ultimately increase nutrient uptake and caused enhanced cell division and cell enlargement. Increase plant height with increasing frequency of irrigation also reported by Nandan and Prasad (1998).

Similarly, Leaf area index and dry matter production was found to be significantly influenced at harvest. Irrigation at 1.0 IW/CPE resulted in 4.4 and 4.7 percent increase in LAI over irrigation scheduling at 0.8 IW/CPE in first and second year, respectively. This was due to beneficial effect of adequate soil moisture in maintaining the cell turgidity and cell elongation. These results corroborate with the findings of Kundu *et al.,* (2008).

Seed and haulm yield of Rajmash was significantly influenced by different irrigation schedules during both the years of study. Highest seed and haulm yield of Rajmash was observed with irrigation scheduling at 1.0 IW/CPE ratio and lowest was with irrigation scheduling at 0.8 IW/CPE ratio during both the years of investigation. Scheduling of irrigation at 1.0 IW/CPE recorded 10.9 per cent more seed yield (mean of two years) over irrigation at 0.8 IW/CPE. This might be due to favourable maintenance of soil moisture by supplying water in consonance with physical demands and favourable influence on crop growth and development. All these, resulted in better growth of crop and significant increase in yield attributes terminating in better seed yield. Increase in seed yield with increase in frequency of irrigation was reported by Patil *et al*. (2006) and Behura *et al*., (2008). Scheduling of irrigation at 1.0 IW/CPE recorded 10.9 per cent more haulm yield (mean of two years) over irrigation at 0.8 IW/CPE. This might be attributed to better vegetative growth and higher dry matter production compared to 0.8 IW/CPE ratio. These results corroborate with the findings of Singh *et al.,* (1996).

3. Effect of Fertility treatments on growth attributes and yield.

a. Maize

Fertility treatments brought variation in growth parameters. Maximum plant height was observed at harvest of crop growth with the higher fertility level of 240:00:40 kg NPK ha^{-1} (F_4) whereas, lowest plant height was found with the fertility level of 120:00:40 kg NPK ha^{-1} (F_2). Maize crop responded to higher nitrogen level and resulted in maximum plant height as compared to lower nitrogen levels. Similar results of increased plant height with increased nitrogen levels were reported by Singh *et al.,* (2003). But the leaf number was not influenced by increasing nitrogen levels during both the years. However, its influence was seen in leaf area index. The same kind of observations were recorded as that in case of plant height. Increase in LAI by higher N fertility level was due to increased supply of nitrogen and more uptake of soil P, had shown favorable effect on cell enlargement and cell division, resulting in larger leaves. Similar findings were reported by Arya and Singh (2001).

Table: 1: Mean Plant height (cm), number of green leaves plant^{-1}, Mean leaf area index and Dry matter (kg ha^{-1}) as influenced by different treatments at harvest of Maize.

Treatments	First year				Second year			
	Plant height (cm)	No. of green leaves	Mean leaf area	Dry matter (kg ha^{-1})	Plant height (cm)	No. of green leaves	Mean leaf area index	Dry matter (kg ha^{-1})
I) Main plot treatments								
a) Green leaf manuring options								
M_0-No green leaf manure	174.7	6.7	0.91	11547	194.2	6.8	0.98	12434
M_1- Dhaincha GLM @ 10 t ha^{-1}	187.4	7.0	1.21	13578	206.7	6.9	1.01	13827
M_2- Sunhemp GLM @ 10 t ha^{-1}	184.6	7.0	1.16	13303	205.3	7.0	0.99	13496
SEm±	1.09	0.21	0.04	174.2	1.27	0.13	0.02	189
C.D. @ 5%	2.42	NS	0.1	388	2.83	NS	NS	421
b) Irrigation levels								
I_1- Rainfed	173.8	6.8	1.03	12250	196.9	6.8	0.95	12710
I_2- Irrigation at 1.0 IW/CPE ratio	190.7	7.1	1.16	13369	207.2	7	1.04	13795
SEm±	0.89	0.17	0.04	142.3	1.04	0.11	0.02	154.2
C.D. at 5%	1.98	NS	0.08	317	2.31	NS	0.04	344
II) Sub plot treatments								
Fertility levels								
F_1- 120:60:40 kg NPK ha^{-1}	180.4	7.0	1.08	12107	201	7.0	1.02	12901
F_2-120:00:40 kg NPK ha^{-1}	175.5	6.7	0.92	11730	196.1	6.7	0.88	11885
F_3-180:00:40 kg NPK ha^{-1}	185.6	7.0	1.19	12878	204.2	7.0	1.04	13677
F_4-240:00:40 kg NPK ha^{-1}	187.4	7.1	1.21	14123	207	7.1	1.04	14547
SEm±	1.25	0.24	0.05	221.2	1.47	0.15	0.02	127.95
C.D. at 5%	2.56	NS	0.1	411	3	NS	0.05	261.28

Table 2: Grain yield andstover yield (Kg ha^{-1}) of maize as influenced by green leaf manuring options, irrigation and fertility levels.

Treatments	First year		Second year	
I) Main plot treatments a) Green leaf manuring options	Grain yield Kg ha^{-1}	Stover yield Kg ha^{-1}	Grain yield Kg ha^{-1}	Stover yield Kg ha^{-1}
M_0-No green leaf manure	4255	7041	4305	7232
M_1- Dhaincha GLM @ 10 t ha^{-1}	5180	8549	5318	8849
M_2- Sunhemp GLM @ 10 t ha^{-1}	5102	8447	5242	8731
SEm±	168	275	171	206
C.D. @ 5%	375	610	380	458
b) Irrigation levels				
I_1- Rainfed	4401	7404	4597	7744
I_2- Irrigation at 1.0 IW/CPE ratio	5290	8620	5313	8798
SEm±	138	223	139	168
C.D. at 5%	306	498	310	374
II) Sub plot treatments				
Fertility levels				
F_1- 120:60:40 kg NPK ha^{-1}	4674	7742	4663	7831
F_2-120:00:40 kg NPK ha^{-1}	4192	7064	4375	7393
F_3-180:00:40 kg NPK ha^{-1}	5138	8453	5237	8705
F_4-240:00:40 kg NPK ha^{-1}	5379	8790	5545	9154
SEm±	195	316	197	238
C.D. at 5%	397	645	402	485

Table 3: Mean plant height (cm), number of green leaves plant^{-1}, Mean leaf area index & Dry matter (kg ha^{-1}) as influenced by different treatments at harvest of Rajmash.

Treatments	First year			Second year		
I) Main plot treatments a) Green leaf manuring options	Plant height (cm)	Mean leaf area index	Dry matter (kg ha^{-1})	Plant height (cm)	Mean leaf area index	Dry matter (kg ha^{-1})
M_0-No green leaf manure	36.6	0.77	2240	30.8	0.65	2514
M_1- Dhaincha GLM @ 10 t ha^{-1}	40.2	0.87	2763	35.6	0.76	3060
M_2- Sunhemp GLM @ 10 t ha^{-1}	39.7	0.84	2758	35.0	0.73	3032
SEm±	0.49	0.02	94.2	0.6	0.03	92
C.D. @ 5%	1.1	0.06	210	1.34	0.06	204.9
b) Irrigation levels						
I_1- Rainfed	38	0.80	251	33.0	0.7	2708
I_2- Irrigation at 1.0 IW/CPE ratio	39.5	0.86	2725	34.4	0.75	3028
SEm±	0.4	0.02	77	0.5	0.02	75.1
C.D. at 5%	0.9	0.05	171	1.11	N.S.	167
II) Sub plot treatments						
Fertility levels						
F_1- 120:60:40 kg NPK ha^{-1}	39.1	0.91	2920	33.6	0.8	3130
F_2-120:00:40 kg NPK ha^{-1}	36.8	0.74	2147	31.1	0.64	2442
F_3-180:00:40 kg NPK ha^{-1}	39.1	0.81	2521	34.4	0.7	2821
F_4-240:00:40 kg NPK ha^{-1}	40.3	0.86	2780	35.7	0.75	3001
SEm±	0.57	0.03	133.2	0.7	0.03	106.2
C.D. at 5%	1.16	0.06	297	1.43	0.07	217

Table 4: Seed and haulm yield of Rajmash (Kg ha^{-1}) as influenced by different green leaf manuring options, irrigation and fertility levels.

Treatments	First year		Second year	
I) Main plot treatments a) Green leaf manuring options	Seed yield (Kg ha^{-1})	Haulm yield (Kg ha^{-1})	Seed yield (Kg ha^{-1})	Haulm yield (Kg ha^{-1})
M_0-No green leaf manure	875	1237	1007	1561
M_1- Dhaincha GLM @ 10 t ha^{-1}	1108	1600	1274	1975
M_2- Sunhemp GLM @ 10 t ha^{-1}	1081	1563	1243	1926
SEm±	28.2	29.8	32.4	50.2
C.D. @ 5%	62.7	66.3	72.1	11.8
b) Irrigation levels				
I_1- Irrigation at 0.8 IW/CPE ratio	972	1386	1118	1732
I_2- Irrigation at 1.0 IW/CPE ratio	1071	1548	1232	1909
SEm±	23	24.3	26.4	41
C.D. at 5%	51.2	54.1	58.9	91.3
II) Sub plot treatments				
Fertility levels				
F_1- 40:60:30 kg NPK ha^{-1}	1131	1593	1301	2017
F_2-40:00:30 kg NPK ha^{-1}	853	1200	981	1520
F_3-60:00:30 kg NPK ha^{-1}	990	1448	1139	1765
F_4-80:00:30 kg NPK ha^{-1}	1111	1625	1278	1981
SEm±	32.5	34.4	37.4	57.9
C.D. at 5%	66.4	70.2	76.3	118.3

Highest dry matter production of maize was recorded with higher nitrogen level of 240 kg N ha^{-1} while lowest dry matter production was recorded with 120 kg N ha^{-1}. Fertility levels, F_1 and F_4 production 6.4, 16.7 and 6.2, 14.7 per cent increase in dry matter over RDF (F_1) in first and second year, respectively. More plant height and LAI resulted in better interception and utilization of radiant energy, leading to higher photosynthetic rate, which ultimately resulted in higher accumulation of dry matter. Enhanced dry matter with increase in nitrogen level was reported by Singh *et. al.* (2003).

Yield of a crop is a complex function of genetic makeup and agro-climatic characteristics. Perusal of data on grain and stover yield of maize revealed that fertility level of 240:00:40 kg NPK ha^{-1} (F_4) resulted in significantly higher grain and stover yield of maize, while lowest grain yield was obtained with the fertility level of 120:00:40 kg NPK ha^{-1} (F_2). The fertility level of 240:00:40 kg NPK ha^{-1} (F_4) and180:00:40 NPK kg ha^{-1} (F_3) recorded 17.0 and 11.1 per cent (mean of two years) increase in grain yield respectively over recommended fertilizer dose of 120:60:40 NPK kg ha^{-1} (F_1). Application of 240 kg N ha^{-1} (F_4) and 180 kg N ha^{-1} (F_3) with recommended level potassium recorded 10.0 and 15.2 per cent (mean of two years) increase in stover yield respectively over recommended fertilizer dose of 120:60:40 NPK kg ha^{-1} (F_1). The nitrogen nutrition might have improved source-sink relationship, with better translocation of photsynthates for grain formation. The available nutrients in the soil cannot be utilized efficiently if optimum of required nitrogen is not available to the crop. Increasing levels of nitrogen might have increased the native soil phosphorus availability through the synergistic effect of N and P. All the above conditions coupled with recommended potassium application resulted in higher grain yield. The increased stover yield with increasing nitrogen levels can be attributed to significant increase in plant height accompanied by a larger leaf area. Both these beneficial effects were reflected in higher dry matter production, ultimately resulting in significantly higher stoveryield. The increase in grain yield with increasing levels of nitrogen was reported by Selvaraju (1994), Singh *et al.,* (2003) and Kumar and Singh (2003).

b. Rajmash

Plant height of rajmash significantly differed at harvest of crop due to various fertility levels during both the years of investigation. Maximum plant height was noticed with the fertility level of 80:00:30 kg NPK ha^{-1}(F_4) and lowest with the fertility level of 40:00:30

kg NPK ha^{-1} (F_2) at harvest during both the years of investigation. However, plant height observed due to fertility levels F_1, F_3 and F_4 was on par with each other at harvest of crop during both the years of investigation. Increased plant height due to increase in nitrogen application was reported by Dwivedi *et al*., (1994) and Nandan and Prasad (1998).

Higher leaf area index and dry matter production was recorded with the fertility level of 40:60:30 kg NPK ha^{-1} (F_1) and lowest with fertility level of 40:00:30 kg NPK ha^{-1} (F_2) harvest of crop during both the years of study.However, the fertility level of 40:60:30 kg NPK^{-1} (F_1) and fertility level of 80:00:30 kg NPK ha^{-1} (F_4) recorded on par leaf area index at harvest of crop during both the years of study. Highest LAI in fertility level of 40:60:30 kg NPK ha^{-1} (F_1) was due to application of recommended level of nutrients from extraneous source. Increased availability of all the nutrients, in adequate amounts and their favourable effect on cell enlargement and cell multiplication resulted in larger leaves during both the years of study. Increased dry matter production with increased nitrogen might be attributed to the fact that adequate supply of nitrogen helps in maintaining higher auxin levels which in turn might have had favourable effect on cell enlargement and cell division, release of P in the initial stages of crop growth could have helped in root development and nodulation and meeting the nutrient needsof the crop as RDF treatment. Increase in dry matter due to increase in nitrogen application was also reported by Ali and Tripathi (1988).

Highest Seed and Haulm yield of Rajmash was obtained with fertility level of 40:60:30 kg NPK^{-1} (F_1) and it was on par with the fertility level of 80:00:30 kg NPK ha^{-1} (F_4), while lowest seed and haulm yields was observed with the fertility level of 40:00:30 kg NPK ha^{-1} (F_2) during both the years of investigation. Application of 40 kg N ha^{-1} (F_2), 60 kg N ha^{-1} (F_3) and 80 kg N ha^{-1} (F_4) without phosphorus and with uniform potassium dose recorded 25.5, 12.3 and 1.8 percent less seed yield of rajmash (mean of two years) than recommended dose of fertilizer respectively. The beneficial effect of adequate nutrients resulted in better growth and yield attributes and reflected in higher seed yield of rajmash. Further, higher nitrogen nutrition might have improved source-sink relationship, with better translocation of photosynthetes for grain formation. The increased haulm yield with RDF and 80 kg N ha^{-1} can be attributed to significant increase in plant height accompanied by a larger leaf area. Both these beneficial effects were reflected in higher dry matter production, ultimately resulting in significantly higher haulm yield. The increase in seed and haulm yield with increase in levels of nitrogen was reported by Sharma (2001) and Behura *et al.,* (2008).

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