Indian Journal of Plant Sciences ISSN: 2319-3824 (Online)
An Online International Journal Available at http://www.cibtech.org/jps.htm
2012 Vol. 1 (2-3) Jul.-Sept. & Oct.-Dec., pp.167-176/Selvaraj and Prasanna
Research Article

DRY MATTER PRODUCTION, YIELD ATTRIBUTES, YIELD AND QUALITY OF CLUSTERBEAN [(*CYAMOPSIS TETRAGONOLOBA* (L.) TAUB.] AS INFLUENCED BY NITROGEN AND ZINC APPLICATION

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ABSTRACT
A field experiment was conducted during early *kharif* of 2008 on sandy clay loam soils of dryland farm of Sri Venkateswara Agricultural College, Tirupati to study the effect of nitrogen and zinc on yield and quality of guar (*Cyamopsis tetragonoloba (L)* Taub.). "The experiment was laid out in a split-plot design and replicated thrice. The treatments consisted of three main plots viz., 20 Kg N ha^{-1} (N_1), 30 Kg N ha^{-1} (N_2) and 40 Kg N ha^{-1}(N_3) and four sub plot treatments viz; 0.5 % $ZnSO_4$ spray at 25 DAS (Z_1), 0.5 % $ZnSO_4$ spray at 45 DAS (Z_2), 0.5 % $ZnSO_4$ spray at 25 and 45 DAS (Z_3) and basal application of 20 Kg $ZnSO_4$ ha^{-1}(Z_4). At all the crop growth stages, nitrogen levels significantly influenced the dry matter production. The highest dry matter production was registered with N_3 (40 Kg N ha^{-1}), while it was the lowest with N_1 (20 Kg N ha^{-1}). Yield attributes viz., number of clusters $plant^{-1}$, number of pods $cluster^{-1}$, number of pods $plant^{-1}$, pod length, number of seeds pod^{-1} and thousand seed weight were highest with N_2 (30 Kg N ha^{-1}), while they were at their lowest with N_3 (40 Kg N ha^{-1}) except clusters $plant^{-1}$ and pod length, which were lowest with N_1 (20 Kg N ha^{-1}).The seed yield and stalk yield were highest with N_2 (30 Kg N ha^{-1}) and they were at their lowest with N_1 (20 Kg N ha^{-1}). Among the zinc management practices Z_3 (0.5 % $ZnSO_4$ spray at 25 and 45 DAS) resulted in highest seed and stalk yield. Application of 20 Kg $ZnSO_4$ ha^{-1} (Z_4) recorded the lowest yield. With regard to quality parameters, protein content was found to be the highest with N_3 (40 Kg N ha^{-1}), which was however, comparable with N_2 (30 Kg N ha^{-1}) and it was lowest with N_1 (20 Kg N ha^{-1}). The highest protein content was recorded with Z_3 (0.5 % $ZnSO_4$ spray at 25 and 45 DAS), while it was lowest with Z_4 (20 Kg $ZnSO_4$ ha^{-1}). The combination of nitrogen levels and zinc management practices could not influence the protein content. The highest post harvest status of soil available phosphorus and potassium was recorded with N_2 (30 Kg N ha^{-1}).

Key Words: *Dry Matter, Yield, Quality, Nitrogen, Zinc, Clusterbean*

INTRODUCTION

Clusterbean is grown for different purposes from very ancient time *viz.*, vegetables, green fodder, and green manure and for production of seeds. Clusterbean seed is used as a concentrate for animals and for extraction of gum. Seeds of clusterbean containing 28-33% gum. The gum has its use in almost all types of industries *viz.*, textiles, paper, petroleum, pharmaceuticals, food processing, cosmetics, mining explosives, oil drilling etc. India is earning crores in foreign exchange every year by exporting guar gum and recorded Rs. 731 crore was obtained in year 1998-99 (Anonymous, 2000). Therefore, India occupies top position in world trade of guar gum. The by product from gum extraction process is of a high value protein feed for cattle as it contains about 40% protein. Improving soil fertility is one of the most common tactics to increase agricultural production. Maintaining high levels of available Nitrogen and zinc, the two most limiting nutrients in soils, is a major challenges to ecologists and land managers. Nitrogen is essential for normal growth and development of clusterbean. Besides all these, it provides nutritive concentrate and adds to the fertility of soil by fixing considerable amount of atmospheric nitrogen (Naagar *et al.*, 2004). Earlier reports showed that combine application of nitrogen and zinc caused significant results in respect of grain yield and quality of crop. Therefore keeping this in view, present study on effect of nitrogen and zinc on drymatter production, yield and quality of clusterbean crop was undertaken.

MATERIALS AND METHODS

A field experiment conducted during early Kharif, 2008 at S.V. Agricultural College, Tirupati. The soil of the experimental site was sandy loam with pH 7.1, organic carbon 0.25%, available N 240 kg ha^{-1}, available P_2O_5 25 kg ha^{-1}, and K_2O 229.7kg ha^{-1} and zinc 0.7 mg kg^{-1}. The experiment was laid out in spit plot design with twelve treatment replicated thrice. The fertilizers were applied as per treatments. Entire quantity of N, P_2O_5 and K_2O was applied as a basal dose. Nitrogen was applied as per the main plot treatments i.e. N_1 @ 20 kg ha^{-1}, N_2 @ 30 kg ha^{-1} and N_3 @ 40 kg ha^{-1}. The zinc was applied as per the sub plot treatments i.e. Z_1 –@ 0.5% $ZnSO_4$ spray at 25 DAS, Z_2 @ 0.5% $ZnSO_4$ spray at 45 DAS, Z_3 @ 0.5% $ZnSO_4$ spray at 25 and 45 DAS, Z_4 @ 20 kg $ZnSO_4$ ha^{-1}.

The source of N, P, K and Zn are urea, single super phosphate, muriate of potash and zinc sulphate, respectively. The fertilizers were placed in the furrows made with hand hoe 5 cm away from seed rows and at a depth of 5 cm below the seed zone. The variety used in the experiment was “RGM 112”. It is recommended for arid and semi-arid tract of the country and resistant to white fly. Agronomic Cultivation practices like field preparation, seeds and sowing, weeding, fertilizer application, and other plant protection measures were done for healthy crop growth and yield dada observed in specific growth stages particularly 25, 50 and 75 DAS.

For dry matter production, five plants were selected at random from border rows leaving the extreme row in each plot and the plants were cut, air dried and then oven dried at 60°C, till constant weight was obtained and their weights were recorded. Dry matter production was recorded at 25, 50, 75 DAS and at harvest and expressed as kg ha^{-1}. Similarly number of cluster per plant, number of pods per cluster, number of pods per plant, pod length, number of seeds per pod, thousand seed weight, seed yield and stalk yield are observed in appropriate plant growth stage.

Similarly in quality parameters crude protein content (%) and crude gum content (%) are analyzed by Microkjeldhal method (Juliano *et al*., 1973) and Das method (Das *et al*., 1977) respectively.

RESULTS AND DISCUSSION

i) ***Dry Matter Production:*** Dry matter production of guar increased progressively with advance in age of the crop up to maturity.

a) ***Dry Matter Production at 25 DAS***

Nitrogen levels and zinc management practices significantly influenced the dry matter production but their interaction could not show any significant effect (Table -1).

The highest dry matter production was noticed with N_3 (40 Kg N ha^{-1}) which was significantly superior to rest of the nitrogen levels. The next best treatment was N_2 (30 Kg N ha^{-1}) which was distinctly superior to N_1 (20 Kg N ha^{-1}). The highest dry matter production was recorded with Z_4 (20 Kg $ZnSO_4$ ha^{-1}) and it was superior over the remaining three treatments which were found to be inferior and at par with each other. Significant interaction was not traceable between nitrogen levels and zinc management practices with regard to dry matter production.

b) ***Dry Matter Production at 50 DAS***

Among the nitrogen levels, N_2 (30 Kg N ha^{-1}) has resulted in maximum dry matter production which was distinctly superior to the remaining two treatments, N_3 (40 Kg N ha^{-1}) and N_1 (20 Kg N ha^{-1}). The lowest dry matter was recorded with N_1 (20 Kg N ha^{-1}) (Table - 2).

Zinc management practices significantly influenced the dry matter production at 50 DAS. The highest dry matter production was obtained with Z_3 (0.5 % $ZnSO_4$ spray at 25 and 45 DAS) which was distinctly superior to the remaining treatments. The next best treatment was Z_1 (0.5 % $ZnSO_4$ spray at 25 DAS) followed by Z_2 (0.5 % $ZnSO_4$ spray at 45 DAS). The lowest dry matter production was resulted with Z_4

Table 1: Dry matter production (kg ha-1) of guar at 25 and 75 DAS as influenced by nitrogen and zinc nutrition

Treatments	Dry Matter Production		
	25 DAS	75 DAS	At Harvest
Nitrogen levels			
N_1	241	9991	10441
N_2	272	11013	11171
N_3	281	12700	12573
SEm±	1	191	175
CD (P = 0.05)	6	750	689
Zinc management practices			
Z_1	262	11596	11916
Z_2	260	10308	10015
Z_3	258	13764	13811
Z_4	278	9271	9839
SEm±	2	174	398
CD (P = 0.05)	5	518	1182
N x Z	NS	NS	NS

(20 Kg $ZnSO_4$ ha^{-1}). The interactions effect was significant at 50 DAS. Irrespective of nitrogen levels, Z_3 (0.5 % $ZnSO_4$ spray at 25 and 45 DAS) resulted in highest dry matter production while at all zinc management practices, application of 30 Kg N ha^{-1} (N_2) resulted in highest dry matter production. The highest dry matter production was obtained with N_2Z_3 (30 Kg N ha^{-1} along with 0.5 % $ZnSO_4$ spray at 25 and 45 DAS) while N_1Z_4 (20 Kg N ha^{-1} along with 20 Kg $ZnSO_4$ ha^{-1}) accounted for the lowest dry matter production.

Table 2: Dry matter production (kg ha-1) of guar at 50 DAS as influenced by nitrogen and zinc nutrition

Treatments	Z_1	Z_2	Z_3	Z_4	Mean
N_1	2923	2649	3722	1842	2784
N_2	3680	3122	5008	2589	3599
N_3	3466	3050	4499	2611	3406
Mean	3356	2940	4410	2348	

Interaction	SEm ±	CD (0.05)
N	29	115
Z	40	117
N at Z	66	208
Z at N	68	203

c) *Dry Matter Production at 75 DAS*

Significant disparity in dry matter production at 75 DAS was noticed due to nitrogen levels and zinc management practices (Table -1).

The highest dry matter production was with N_3 (40 Kg N ha^{-1}) followed by N_2 (30 Kg N ha^{-1}) while the lowest dry matter production was obtained with N_1 (20 Kg N ha^{-1}). Significantly highest dry matter production was recorded with Z_3 (0.5 % $ZnSO_4$ spray at 25 and 45 DAS) which was significantly superior to the remaining treatments and Z_2 (0.5 % $ZnSO_4$ spray at 45 DAS) was the next best treatment. The lowest dry matter production was recorded with Z_4 (20 Kg $ZnSO_4$ ha^{-1}).

The interaction effect of nitrogen levels and zinc management practices failed to exert any significant influence on dry matter production at 75 DAS

d) *Dry Matter Production at Harvest*

The highest dry matter production was obtained with N_3 (40Kg N ha^{-1}) followed N_2 (30 Kg N ha^{-1}). Application of 20 Kg N ha^{-1}(N_1) was found to record the lowest dry matter production (Table -1).

The highest dry matter production was recorded with Z_3 (0.5 % $ZnSO_4$ spray at 25 and 45 DAS) which was significantly superior to the remaining treatments. The next best treatment was found to be Z_1 (0.5 % $ZnSO_4$ spray at 25 DAS). The lowest dry matter production was observed with Z_4 (20 Kg $ZnSO_4$ ha^{-1}) which was comparable with Z_2 (0.5 % $ZnSO_4$ spray at 45 DAS).

Interaction effect of nitrogen levels and zinc management practices was found to be non significant. Enhanced dry matter production with adequate supply of nitrogen, as evidenced in this investigation corroborates the findings of Mohmoud *et al.,* (1996); Sanjeev Kumar *et al.,* (2007) and Uday Burman *et al.,* (2007).

ii) ***Yield Attributes and Yield***

a) *Number of Clusters Plant^{-1}:* Nitrogen levels, zinc management practices as well as their interaction effect exerted significant influence on the number of clusters $plant^{-1}$ in guar (Table - 3).

Table 3: Yield attributes of guar as influenced by nitrogen and zinc nutrition

Treatments	Z1			Z2			Z3			Z4			Mean		
	Cluster/plant	Pod/cluster	Pods/plants	Cluster/plant	Pod/cluster	Pods/plants	Cluster/plant	Pod/cluster	Pods/plants	Cluster/plant	Pod/cluster	Pods/plants	Cluster/plant	Pod/cluster	Pods/plants
N1	17.3	3.2	53.7	18.0	2.8	48.6	22.3	3.6	76.6	18.3	2.5	43.1	19.0	3.0	55.5
N2	19.7	4.4	76.3	18.3	3.7	54.8	26.0	5.0	105.9	18.3	3.4	50.2	20.6	4.1	71.8
N3	19.0	3.1	50.4	17.0	2.9	43.3	26.0	3.5	81.9	16.7	2.4	39.5	19.7	3.0	53.8
Mean	18.7	3.5	60.1	17.8	3.1	48.9	24.8	4.0	88.1	17.8	2.8	44.2	--	--	--

Interaction	SEm±			CD (0.05)		
	Cluster/ plant	**Pod/ cluster**	**Pods/ plants**	**Cluster/ plant**	**Pod/ cluster**	**Pods/ plants**
N	0.23	0.051	0.82	0.9	0.2	3.2
Z	0.34	0.054	1.09	1.0	0.2	3.3
N at N	0.55	0.096	1.83	1.7	0.3	5.8
Z at N	0.58	0.093	1.89	1.7	0.3	5.6

The highest number of clusters $plant^{-1}$ was recorded with N_2 (30 Kg N ha^{-1}), which was on par with N_3 (40 Kg N ha^{-1}). The lowest number of clusters $plant^{-1}$ was observed in N_1 (20 Kg N ha^{-1}) which was in parity with N_3 (40KgNha^{-1}). Application of 0.5 % $ZnSO_4$ spray at 25 and 45 DAS (Z_3) resulted in the highest number of clusters $plant^{-1}$. The lowest number of clusters $plant^{-1}$ was recorded with Z_4 (20 Kg

$ZnSO_4$ ha^{-1}) and Z_2 (0.5 % $ZnSO_4$ spray at 45 DAS) which were on par with Z_1 (0.5 % $ZnSO_4$ spray at 25 DAS).

b) *Number of Pods Cluster^{-1}:* Number of pods cluster^{-1} was significantly influenced due to nitrogen levels, zinc management practices and also their interaction (Table - 3).

The highest number of pods cluster^{-1} was recorded with N_2 (30 Kg N ha^{-1}) which was significantly superior to rest of the nitrogen levels. The next best treatment was N_1 (20 Kg N ha^{-1}). Application of 40 Kg N ha^{-1} (N_3) was found to be the lowest. The highest number of pods cluster^{-1} was noticed with Z_3 (0.5 % $ZnSO_4$ spray at 25 and 45 DAS) which was significantly superior to other levels. The next best treatment was Z_1 (0.5 % $ZnSO_4$ spray at 25 DAS) followed by Z_2 (0.5 % $ZnSO_4$ spray at 25DAS). The lowest number of pods cluster^{-1} was observed in Z_4 (20 Kg $ZnSO_4$ ha^{-1}).

The interaction effect of nitrogen levels and zinc management practices was conspicuous. Irrespective of the Zinc management practices, application of 30 Kg N ha^{-1} (N_2) produced more number of pods cluster^{-1}. At all the nitrogen levels, Z_3 (0.5 % $ZnSO_4$ spray at 25 and 45 DAS) recorded more number of pods cluster^{-1}. The highest number of pods cluster^{-1} was recorded with N_2Z_3 (30Kg N ha^{-1} along with 0.5 % $ZnSO_4$ spray at 25 and 45 DAS). Application 30KgN ha^{-1} along with 0.5 % $ZnSO_4$ spray at 25DAS (N_2Z_1) was found to be the next best. The lowest number of pods cluster^{-1} was found with N_3Z_4 (40Kg N ha^{-1} along with 20 Kg $ZnSO_4$ ha^{-1}) and was on par with N_1Z_4 (20 Kg N ha^{-1} along with 20 Kg $ZnSO_4$ ha^{-1}).

c) *Number of Pods Plant^{-1}:* Nitrogen levels and zinc management practices as well as their interaction have exerted significant influence on number of pods plant^{-1} (Table - 3).

Application of 30 Kg N ha^{-1} (N_2) has resulted in highest number of pods plant^{-1} which was significantly superior to rest of the nitrogen levels. Application of 40 Kg N ha^{-1} (N_3) was found to be inferior but was comparable with N_1 (20 Kg N ha^{-1}). Application of 0.5 % $ZnSO_4$ spray at 25 and 45 DAS (Z_3) significantly increased the number of pods plant^{-1} compared to other zinc management practices. The next best treatment was Z_1 (0.5 % $ZnSO_4$ spray at 25 DAS) followed by Z_2 (0.5 % $ZnSO_4$ spray at 45 DAS). The lowest number of pods plant^{-1} was noticed with Z_4 (20 Kg $ZnSO_4$ ha^{-1}).

With regard to interaction, application of 0.5 % $ZnSO_4$ spray at 25 and 45 DAS (Z_3) recorded higher number of pods plant^{-1} at all the nitrogen levels tried. Irrespective of zinc management practices, N_2 (30 Kg N ha^{-1}) was found to be superior. The highest number of pods plant^{-1} was recorded with N_2Z_3 (30 Kg N ha^{-1} along with 0.5 % $ZnSO_4$ spray at 25 and 45 DAS). The next best treatment was N_3Z_3 (40 Kg N ha^{-1} along with 0.5 % $ZnSO_4$ spray at 25 and 45 DAS) which was however on par with N_1Z_3 (20 Kg N ha^{-1} along with 0.5 % $ZnSO_4$ spray at 25 and 45 DAS) and N_2Z_1 (30 Kg N ha^{-1} along with 0.5 % $ZnSO_4$ spray at 25 DAS). Application of 40Kg N ha^{-1} along with 20 Kg $ZnSO_4$ ha^{-1} (N_3Z_4) was found to be the least performing treatment.

d) *Pod Length:* Pod length was significantly influenced by nitrogen levels and zinc management practices but their interaction could not have any significant effect (Table - 4).

Maximum pod length was recorded in both N_2 (30 Kg N ha^{-1}) and N3 (40 Kg N ha^{-1}) treatments. The shortest pods were observed with N_1 (20 Kg N ha^{-1}).

Application of 0.5 % $ZnSO_4$ spray at 25 and 45 DAS (Z_3) resulted in maximum pod length, while Z_4 (20 Kg $ZnSO_4$ ha^{-1}) was found to record the lowest pod length which was comparable with Z_1 (0.5 % $ZnSO_4$ spray at 25 DAS) and Z_2 (0.5 % $ZnSO_4$ spray at 45 DAS).

The Interaction effect of nitrogen and zinc management practices was found to be non significant.

e) *Number of Seeds Pod^{-1}:* Except Interaction, nitrogen levels and zinc management practices could significantly influence the number of seeds pod^{-1} (Table - 4).

Application of 30 Kg N ha^{-1} (N_2) resulted in the highest number of seeds pod^{-1} which was on par with 20 Kg N ha^{-1} (N_1). The lowest number of seeds pod^{-1} was recorded in N_3 (40 Kg N ha^{-1}). Among the zinc management practices, application of 0.5 % $ZnSO_4$ spray at 25 and 45 DAS (Z_3) was found to record the highest number of seeds pod^{-1}. The next best treatment was Z_1 (0.5 % $ZnSO_4$ spray at 25 DAS) which was however on par with Z_2 (0.5 % $ZnSO_4$ spray at 45 DAS). The lowest number of seeds pod^{-1} was produced in Z_4 (20 Kg $ZnSO_4$ ha^{-1}). Regarding the interaction effect there was no significant influence on number of seeds $pod^{-1.}$

f) ***Thousand Seed Weight:*** Thousand seed weight was found to be significantly influenced only by zinc management practices. Nitrogen levels and interaction could not have any effect on the thousand seed weight (Table - 4).

Table 4: Yield attributes of guar as influenced by nitrogen and zinc nutrition

Treatments	Pod length (cm)	Seeds/ pod	Thousand Seed Weight (g)
Nitrogen levels			
N1	4.9	7.6	34.3
N2	5.1	7.9	33.2
N3	5.1	7.2	33.1
SEm±	0.02	0.08	0.02
CD (P = 0.05)	0.1	0.3	NS
Zinc management practices			
Z_1	5.0	7.6	33.8
Z_2	5.0	7.5	32.7
Z_3	5.3	7.9	35.7
Z_4	4.9	7.3	32.0
SEm±	0.04	0.04	0.02
CD(P=0.05)	0.1	0.1	0.1
N ×Z	NS	NS	NS

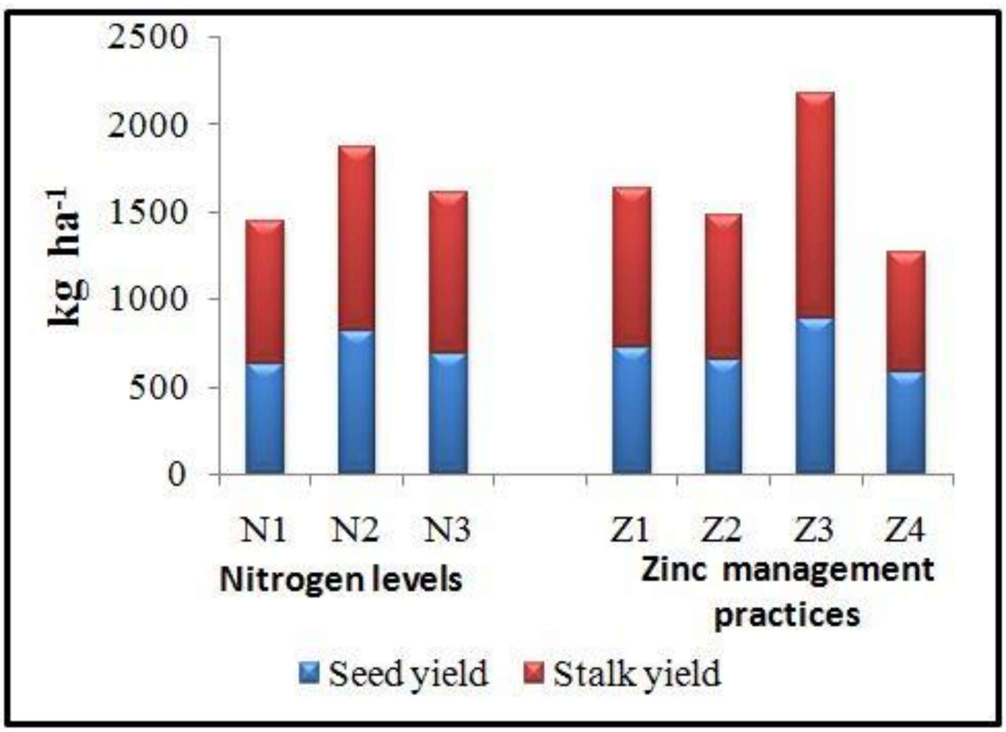

Figure 1: Seed yield and Stalk yield (kg ha^{-1}) of guar as influenced by nitrogen and zinc nutrition

Significantly the highest test weight was obtained with Z_3 (0.5 % $ZnSO_4$ spray at 25 and 45 DAS) followed by Z_1 (0.5 % $ZnSO_4$ spray at 25 DAS). The lowest test weight was recorded with Z_4 (20 Kg $ZnSO_4$ ha^{-1}) which was found significantly inferior to rest of the treatments.
Yield attributes viz., number of clusters $plant^{-1}$, number of pods $cluster^{-1}$, number of pods $plant^{-1}$, pod length, number of seeds pod^{-1} and thousand seed weight were highest with N_2 (30 Kg N ha^{-1}), while they were at their lowest with N_3 (40 Kg N ha^{-1}) except clusters $plant^{-1}$ and pod length, which were lowest with N_1 (20 Kg N ha^{-1}) (Figure 5.4-5.9). Higher dry matter production and the efficient translocation of accumulated assimilates to the reproductive parts under comfortable nitrogen nutrition might be responsible for the beneficial effect on elevating the stature of all the yield attributes. Similar results have been reported by Singh and Singh (1989) and Sharma and Nehara (2004).
g) *Seed Yield*: Seed yield was significantly influenced by nitrogen levels, zinc management practices and their interaction (Table 5. and Figure1).

Table 5: Seed and Stalk yield (kg ha^{-1}) of guar as influenced by nitrogen and zinc nutrition

Treatment	Z1		Z2		Z3		Z4		Mean	
	Seed	Stalk	Seed	Stalk	Seed	Stalk	Seed	Stalk	Seed	Stalk
N1	613	832	559	745	808	1082	513	639	623	825
N2	830	971	727	859	1053	1579	666	770	819	1045
N3	715	945	685	859	813	1197	554	646	692	912
Mean	719	916	657	822	891	1286	577	685	--	--

Interaction	SEm±		CD (0.05)	
	Seed	Stalk	Seed	Stalk
N	10.76	16.72	42	66
Z	14.36	13.77	43	41
N at N	24.08	26.58	76	89
Z at N	24.87	23.86	74	71

The highest seed yield was obtained with N_2 (30 Kg N ha^{-1}) which was superior to all other treatments. The next best treatment was 40 Kg N ha^{-1} (N_3) which was significantly higher compared to 20 Kg N ha^{-1} (N_1). The lowest yield was obtained in N_1 (20 Kg N ha^{-1}). The increase in seed yield with N_2 (30 Kg N ha^{-1}) was 31.5 and 18.3per cent higher than with N_3 (40 Kg N ha^{-1}) and N_1 (20 Kg N ha^{-1}), respectively. Clear disparity in seed yield was noticed between any two of four zinc treatments tried. The highest seed yield was obtained with application of 0.5 % $ZnSO_4$ spray at 25 and 45 DAS (Z_3) which was significantly superior to all other zinc treatments tried. Application of 0.5 % $ZnSO_4$ spray at 25 DAS (Z_1) was the next best treatment followed by Z_2 (0.5 % $ZnSO_4$ spray at 45 DAS). Application of 20 Kg $ZnSO_4$ ha^{-1} (Z_4) resulted in the lowest seed yield. Application of 0.5 % $ZnSO_4$ spray at 25 and 45 DAS (Z_3) increased seed yield by 54.4% over 20 Kg $ZnSO_4$ ha^{-1} (Z_4) while the yield increase was 35.6% and 23.9% over Z_2 (0.5 % $ZnSO_4$ spray at 45 DAS) and Z_1 (0.5 % $ZnSO_4$ spray at 25 DAS), respectively.
Seed yield varied significantly due to the interaction effect of nitrogen levels and zinc management practices. At all the nitrogen levels tried, Z_3 (0.5 % $ZnSO_4$ spray at 25 and 45 DAS) resulted in the highest seed yield. Irrespective of zinc management practices, N_2 (30 Kg N ha^{-1}) resulted in highest seed yield. The highest seed yield was obtained with N_2Z_3 (30 Kg N ha^{-1} along with 0.5 % $ZnSO_4$ spray at 25 and 45 DAS). The lowest seed yield was recorded with N_1Z_4 (20 Kg N ha^{-1} along with 20 Kg $ZnSO_4$ ha^{-1}). Application of 30 Kg N ha^{-1} along with 0.5 % $ZnSO_4$ spray at 25 and 45 DAS (N_2Z_3) increased the seed yield by 105.3% over 20 Kg N ha^{-1} along with 20 Kg $ZnSO_4$ ha^{-1} (N_1Z_4).

Higher guar yield with application of nitrogen, as noticed in the present investigation confirms the documented evidence of Baboo and Rana (1995), Patel *et al.*, (2005), Sharma and Nehara (2004) and Rathore *et al.*, (2007).

h) *Stalk Yield:* Stalk yield was significantly influenced by nitrogen levels, zinc management practices and also their interaction (Table 5 and Figure 1).

The highest stalk yield was obtained with N_2 (20 Kg N ha^{-1}) which was significantly superior to rest of the nitrogen levels. Application of 40 Kg N ha^{-1} (N_3) was the next best treatment. The stalk yield was the lowest with 20 Kg N ha^{-1} (N_1).

The stalk yield was the highest with 0.5 % $ZnSO_4$ spray at 25 and 45 DAS (Z_3) which was significantly superior to all the other zinc management practices. Application of 0.5 % $ZnSO_4$ spray at 25 DAS (Z_1) was found to be the next best treatment followed by 0.5 % $ZnSO_4$ spray at 25DAS (Z_2). The lowest stalk yield was noticed with 20 Kg $ZnSO_4$ ha^{-1}(Z_4).

Irrespective of the zinc management practices imposed, N_2 (30 Kg N ha^{-1}) resulted in highest stalk yield, while at all the nitrogen levels tried, Z_3 (0.5 % $ZnSO_4$ spray at 25 and 45 DAS) accounted for highest stalk yield. Among the interactions, significantly highest stalk yield was recorded with N_2Z_3 (30 Kg N ha^{-1} along with 0.5 % $ZnSO_4$ spray at 25 and 45 DAS). The lowest stalk yield was obtained with N_1Z_4 (20 KgNha^{-1} along with 20 Kg $ZnSO_4$ ha-1) which was comparable with N_3Z_4 (40Kg N ha^{-1} along with 20 Kg $ZnSO_4$ ha^{-1}).

These findings are in conformity with Singh and Singh (1989), Baboo and Rana (1995), Yadav *et al.*, (2003) and Patel *et al.*, (2005).

iii) **QUALITY PARAMETERS**

a) Crude Protein Content

Nitrogen levels and zinc management practices could have significant influence on the protein content but their interaction could not have any significant effect on protein content. (Table - 6).

Table 6: Crude protein content (%), Crude gum content (%) and Gum yield (kg ha^{-1}) of seed as influenced by nitrogen and zinc nutrition.

Treatments	Quality parameters		
	Crude protein content	**Crude gum content**	**Gum content**
Nitrogen levels			
N_1	25.8	30.0	187
N_2	28.0	29.9	235
N_3	28.2	30.1	208
SEm±	0.29	0.15	8.7
CD (P = 0.05)	1.1	NS	34
Zinc management practices			
Z_1	27.8	29.9	206
Z_2	26.7	29.8	168
Z_3	28.9	30.3	264
Z_4	25.9	29.9	176
SEm±	0.22	0.20	9.2
CD (P = 0.05)	0.7	NS	27
N×S	NS	NS	NS

The highest protein content was recorded with N_3 (40 Kg N ha^{-1}), which was on par with N_2 (30 Kg N ha^{-1}). The lowest protein content was recorded with N_1 (20 Kg N ha^{-1}) which was significantly lesser than the other nitrogen levels. Zinc management practices influenced the protein content of guar with distinct disparity between any two zinc treatments tried. Application of 0.5 % $ZnSO_4$ spray at 25 and 45 DAS (Z_3)

recorded the highest protein content followed by Z_1 (0.5 % $ZnSO_4$ spray at 25 DAS) and Z_2 (0.5 % $ZnSO_4$ spray at 45 DAS) with significant disparity among them. The lowest protein content was recorded with Z_4 (20 Kg $ZnSO_4$ ha^{-1}) which was significantly lesser than rest of the treatments. Interaction was not traceable statistically. These results are in agreement with the findings of Singh and Singh (1989) and Baboo and Rana (1995).

B) *Crude Gum Content*

Effect of nitrogen levels, zinc management practices and their interaction could not be statistically traceable (Table -6 and Figure 1).

c) *Gum Yield*

Different treatments had a significant influence on the gum yield but their interaction fails to exert any significant influence on the gum yield (Table -6 and Figure 2).

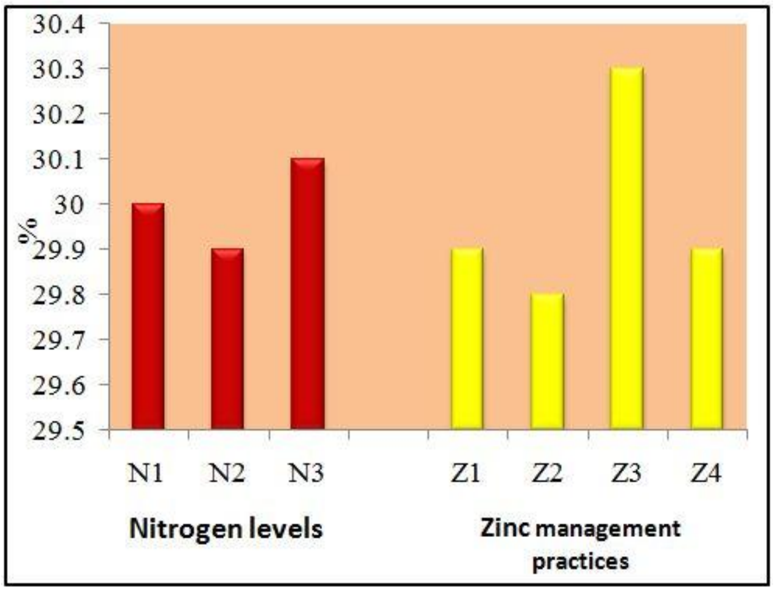

Figure 2: Crude gum content of seed (%) of guar as influenced by nitrogen and zinc nutrition

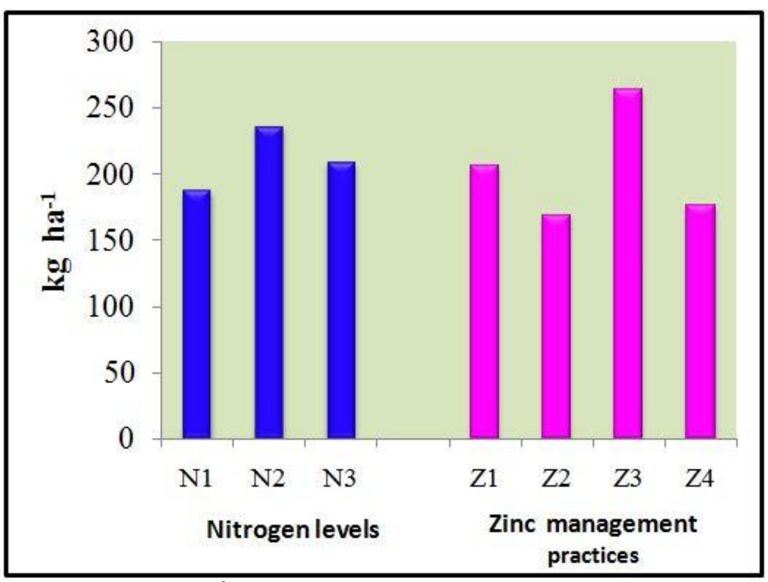

Figure 3: Gum yield (kg ha^{-1}) of guar as influenced by nitrogen and zinc nutrition

The highest gum yield was recorded with N_2 (30 Kg N ha^{-1}), however it was comparable with N_3 (40 Kg N ha^{-1}). The lowest gum yield was obtained with N_1 (20 Kg N ha^{-1}) which was in parity with N_3 (40 Kg N ha^{-1}). Application of 0.5 % $ZnSO_4$ spray at 25 and 45 DAS (Z_3) was found to produce highest gum yield followed by Z_1 (0.5 % $ZnSO_4$ spray at 25 DAS) and Z_4 (20 Kg $ZnSO_4$ ha^{-1}). The lowest gum yield was recorded with Z_2 (0.5 % $ZnSO_4$ spray at 45 DAS) which was comparable with Z_4 (20 Kg $ZnSO_4$ ha^{-1}). Interaction was found to be non-significant.

Based on the present study it can be concluded that application of 30 Kg N ha^{-1} (N_2) was found to be effective and economic for higher yield and returns. The treatment Z_3 (0.5 % $ZnSO_4$ spray at 25 and 45DAS) registered the highest seed yield and better economic returns. Application of 30 Kg N ha^{-1} (N_2) along with 0.5 % $ZnSO_4$ spray at 25 and 45DAS (Z_3) performed better than other interactions in terms of growth and yield of guar. The combination of nitrogen levels and zinc management practices could not influence the protein content. Neither nitrogen levels, zinc management practices nor could their interaction significantly influence the gum content.

REFERENCES

Anonymous (2000). Industry, market size and shares. CMIE.

Baboo R and Rana NS (1995). Nutrient uptake and yield of clusterbean (*Cyamopsis tetragonoloba*) as influenced by nitrogen, phosphorus and seed rate. *Indian Journal of Agronomy* **40**(3) 482-485.

Das B, Arora SK and Luthra Y P (1977). A rapid method for determination of gum in guar (*Cyamopsis tetragonoloba* (L.) Taub). Proceedings of Ist ICAR Guar Research Workshop, Jodhpur 117-123.

Juliano BO, Antonio AA and Esmama BV (1973). Effect of protein content on the distribution and properties of rice protein. *Journal of the Science, Food and Agriculture* **24** 295-306.

Mahmoud SM, Badawy FH, Gameh MA and Sadiek HS (1996). Effect of inoculation of pigeon pea, siratro and guar with *Bradyrhizobium* strains, nitrogen and phosphorus fertilization on: II forage crop yield. *Assiut Journal of Agricultural Science* **27**(1) 17-32.

Naagar K and Meena NC (2004). Effect of phosphorus, sulphur and phosphate solubilizing bacteria on yield component, yield and quality of clusterbean *Cyamopsis tetragonoloba* (L.)**.** Legume Research **27**(1) 27-31.

Patel IC, Patel MM, Patel AG and Tikka SBS (2005). Response of *kharif* guar to fertilizers and row spacing under rainfed conditions. *Indian Journal of Pulses Research* **18**(2) 246-247.

Rathore V S, Singh JP, Soni M L, Yadava N D and Beniwal RK (2007). Effect of nutrient management on growth, productivity and nutrient uptake of rainfed clusterbean (*Cyamopsis tetragonoloba*) in arid regions. *Indian Journal of Agricultural Science* **77**(6) 349-353.

Sanjeev Kumar Baboo R and Kumar M (2007). Response of guar (*Cyamopsis tetragonoloba* L.) to rhibozbium inoculation, nitrogen and phosphorus. *Progressive Agriculture* **7** (1/2) 147-148.

Sharma S K and Nehara K C (2004). Effect of different varieties and fertilizer levels on yield and yield attributing characters of guar (*Cyamopsis tetragonoloba* (L) Taub.). *National Symposium on Arid Legumes for Sustainable Agriculture and Trade* 51.

Singh RV and Singh RR (1989). Effect of nitrogen, phosphorus and seeding rates on growth, yield and quality of guar under rainfed conditions. *Indian Journal of Agronomy* **34**(1) 53-56.

Uday Burman, Balvinder Kumar Garg and Shyam Kathju (2007). Interactive effects of phosphorus, nitrogen, and thiourea on clusterbean [*Cyamopsis tetragonoloba* L.] under rainfed conditions of the Indian arid zone. *Journal of Plant Nutrition and Soil Science* **170**(6) 803-810.

Yadav BD, Joshi UN and Joon RK (2003). Effect of iron and zinc on growth, grain yield and quality of clusterbean. *National Symposium on Arid Legumes for Sustainable Agriculture and Trade* 68.