*The Andhra Agric. J* 65 (1): 58-64, 2018

# Growth and yield of clusterbean as influenced by fertilizer application in arid region of Andhra Pradesh

**C Radha Kumari and B Sahadeva Reddy**

Agricultural Research Station, ANGRAU, Anantapuram -515 001

**ABSTRACT**

A field experiment was conducted to study fertilizer management in clusterbean in alfisols of scarce rainfall zone under rainfed conditions for three years during kharif, 2013-14, 2014-15 and 2015-16 at Agricultural Research Station, Ananthapuram of Andhra Pradesh. Pooled analysis of data revealed that number of pods per plant, seed yield, gross returns, net returns and B:C ratio was not significantly influenced by different fertilizer management practices. However highest mean number of pods per plant was resulted with application of 20 kg K $ha^{-1}$, seed yield was registered with 20 kg N + 20 kg P + 20 kg K+ 3 kg Bo $ha^{-1}$.Higher gross returnswere realized with 20 kg N + 20 kg P + 20 kg K+ 3 kg Bo $ha^{-1}$, highest net returns obtained with 20 kg N $ha^{-1}$ and highest benefit cost ratio was realized with 20 kg N $ha^{-1}$. Application of 20 kg N $ha^{-1}$ can be recommended to scarce rainfall zone of Andhra Pradesh of for maximization of profits in clusterbean crop.

**Key words:** *Clusterbean, Rainfed Red Soils*

Clusterbean, popularly known as guar is k*harif* legume crop, very drought tolerant, sun-loving but susceptible to frost that requires only 300-400 mm annual rainfall recently classified in arid legume group and is grown for vegetable, green fodder, green manure and for grain. Its deep penetrating root system enables the plant to utilize available moisture more efficiently and thus offers better scope for rainfed cropping. The crop survives best even under moderate salinity and alkalinity. Clusterbean tolerates high temperatures and dry conditions and is adapted to arid and semi-arid climates (Undersander *et al*., 1991). It is a principal source of galactomannan (28 -33 % guar gum) and has numerous food and industrial uses *viz.,* textiles, paper, petroleum, pharmaceuticals, food processing, cosmetics, mining explosives, oil drilling etc. India is leading producer of the crop in the world contributing to around 75-82% of the total production. The consumption pattern of its seed is largely influenced by the demands from the petroleum industries in USA and oil fields in the Middle East. The trend of consumption has also increased in rest of the world that has led to its introduction in many countries.

India is a leading exporter of guar gum with 80% of world production, followed by Pakistan. In India, Rajasthan is the largest clusterbean producing states in the world as it dominates the Indian production scenario contributing to 70% of the total production in India followed by Haryana (12%) and Gujarat (11%). Clusterbean basically grown under arid rainfed conditions and there was year to year huge yield fluctuations due to erratic rainfall (Pathak *et al*., 2009 and Singh *et al*., 2003& 2005).

Clusterbean responds to phosphorus rather than nitrogen. As N fixing legume usually require more P than minimal N fertilizer because P plays very vital role in the nodule development and their activity (Serraj *et al*., 2004). In recent years, the continuous application of only N and P led to the deficiency of micronutrients in arid soils. Deficiency of micro nutrients has great detrimental effects on metabolic pathways, enzyme activities, performance of crops and uptake of macronutrients. Zn application significantly increased the nitrogen activity, carbohydrate and protein content in clusterbean (Nandwal *et al*., 1990). Potassium also plays a critical role under moisture stress conditions through its influence on maintenance of turgor potential photosynthesis, translocation of photosynthetic, starch synthesis and activation of number of enzymes. Vyas *et al*. (2001) found increase in seed yield of arid legumes with increasing K levels even under low levels of soil moisture

availability. Due to moisture scarcity, the soil organic matter turnover and fertilizer use efficiency is very low (Garg and Uday Burman, 2011).

After seeing great revenues with the crop during previous years by Rajasthan farmers, farmers in Ananthapuram, Guntur, Kurnool, Karimnagar, Nellore, Prakasam and Ranga Reddy districts of Andhra Pradesh have also started the cultivation of this crop for seeds in more than 1000 ha. Ananthapuram district is the second most drought - affected district of India. It receives around 500 mm rainfall annually. The agriculture is predominantly dependent on rainfall which is very erratic and uncertain. Being located in the scarce rainfall zone of Andhra Pradesh does not get the full benefit of either the southwest or northeast monsoon. Rainfed agriculture in Anantapuram district is greatly influenced by water shortage caused by low, highly variable and erratic rainfall. In clusterbean information on fertilizer management is meagre for scarce rainfall zone hence present study was initiated.

## MATERIAL AND METHODS

A field experiment was conducted to study fertilizer management in clusterbean in alfisols of scarce rainfall zone under rainfed conditions for three years during *kharif*, 2013-14, 2014-15 and 2015-16 at Agricultural Research Station, Ananthapuram of Andhra Pradesh. The soil of the experimental site was red sandy loam with shallow depth, low in organic carbon (0.34%) and low in available nitrogen (138 kg $ha^{-1}$), medium in available phosphorous (28 kg $ha^{-1}$) and potassium(215 kg $ha^{-1}$).The experiment was laid out in randomized block design withthree replications. The treatments consisted of eleven treatments viz.,$T_1$: Control (No N, P and K), $T_2$: 20 kg N $ha^{-1}$, $T_3$: 20 kg P $ha^{-1}$, $T_4$: 20 kg K $ha^{-1}$, $T_5$: 20 kg N + 20 kg P $ha^{-1}$, $T_6$: 20 kg P + 20 kg K $ha^{-1}$, $T_7$: 20 kg N + 20 kg K $ha^{-1}$, $T_8$: 20 kg N + 20 kg P $ha^{-1}$+ 20 kg K $ha^{-1}$, $T_9$: T8 + 25 kg Zn So4 $ha^{-1}$, $T_{10}$: T8 + 3 kg Bo $ha^{-1}$, $T_{11}$: T8 + 25 kg Zn So4 $ha^{-1}$ + 3 kg Bo $ha^{-1}$. The experimental field was prepared by working with a tractor drawn disc plough and then tractor drawn cultivator was drawn along the field. The individual plots were laid out according to the layout plan. Healthy seeds of clusterbean (var. RGC 1025) with good germination percent (95%) used for sowing purpose As per the treatments N, $P_2O_5$ and $K_2O$ was applied at the time of sowing through urea, single super phosphate and muriate of potash respectively. All other cultural practices were kept normal and uniform for all treatments. At harvest five plants were randomly selected from each treatment for recording growth parameters such as plant height, number of pods per plant, number of seeds per pod, test weight.At harvest in each treatment grain and haulm yield from the net plot (5 m x 5 m) was recorded and expressed in kg $ha^{-1}$.Labour charges, cost of inputs were worked out to compute the cost of cultivation. Gross returns were calculated based on local market prices of clusterbean and net returns by subtracting the total cost of cultivation from gross returns.

## RESULTS AND DISCUSSION

### Rainfall and crop performance

In 2013-14, annual rainfall received (431.8 mm) in 23 rainy days was 75.7% of normal annual rainfall (570 mm). During 2013-14, crop was sown on 12.7.2013 and harvested on 4.10.2013 with crop duration of 85 days. During the crop period 328.4 mm rainfall was received in 11 rainy days (Table 1). In 2014-15, annual rainfall 375.2 mm received in 26 rainy days it was 65.8% of normal annual rainfall (570 mm). During 2014-15, crop was sown on 16.7.2014 and harvested on 10.10.2014 with 86 days crop duration. During this period 160.6 mm rainfall was received in 10 rainy days. In 2015-16, annual rainfall 641 mm received in 44 rainy days it was 108% of normal annual rainfall (590.6 mm). During 2015-16, crop was sown on 19.6.2015 and harvested on 11.9.2015 with a crop duration of 84 days. During this period 212.6 mm rainfall was received in 14 rainy days. The average seed yield during 2015 was higher by 40% and 25% compared to 2013 and 2014 respectively and was attributed to optimum soil moisture resulted through sufficient rainfall received in 14 rainy days during different phenophases especially during pod initiation to pod development and pod development to maturity whereas in 2013, 267.1 mm rainfall received in 8 rainy days during pod development to maturity resulted in excess moisture in soil profile which hindered pod development resulting in less test weight and seed yield. Higher seed yield during 2015 compared to 2013 and 2014 was also attributed to fairly higher test weight.

### Growth

Data pertaining to plant height and yield attributes of clusterbean as influenced by fertilizer management practicespresented in Table 5. Plant height of clusterbean measured atharvestwas

not significantly influenced by differentfertilizer management practices. However, the highest mean plant height was observed with application of 20 kg K $ha^{-1}$.These results are in agreement with Ayub*et al*. (2012) who reported that application of P alone could not produced significantly higher plant height over control treatment. Plant height was not affected significantly due to differentfertilizer management practices as observed in this study is not in line with those of Suzuki *et al.* (1991) who reported an increase in growth with nitrogen application. The contradictory results might have been due to heterogenity in fertility status of soil.

**Yield attributes**

Differentfertilizer management practices had no significant influence on number of pods per plant.However highest mean number of pods per plant was resulted with application of 20 kg K $ha^{-1}$.Number of pods per plantwas not affected significantly due to differentfertilizer management practices as recorded in this study is notin line with those of Suzuki *et al.* (1991) who reported an increase in yieldattributes with nitrogen application.

Number of seeds per pod did not varied significantly due to adopted fertilizer management practices. However highest number of seeds per pod was noticed with 20 kg N + 20 kg P $ha^{-1}$.Burman *et al*. (2007) reported thatapplication of nitrogen (20 kg $ha^{-1}$) in association with P (20 kg $ha^{-1}$) significantly enhanced yield attributes of clusterbean under rainfed condition of Jodhpur in a two years study.Raj Singh and Khan (2002) found that application of 20 kg N and 40 kg P $ha^{-1}$ increased yield attributes of clusterbean under rainfed condition. Fertilizer management practiceshad no significant influence on test weight. However highest test weight was obtained with 20 kg N + 20 kg P + 20 kg K + 25 kg Zn $So_4$ $ha^{-1}$.

**Seed and haulm yield**

Data pertaining to seed, haulm yieldandeconomics of clusterbean as influenced by fertilizer management practicespresented in Table6.Mean seed yield was not influenced significantly due to differentfertilizer management practices. However maximum mean seed yield was registered with 20 kg N + 20 kg P + 20 kg K+ 3 kg Bo $ha^{-1}$followed by 20 kg N $ha^{-1}$treatment. Seed yield was not affected significantly due to differentfertilizer management practices as observed in this study is not in line with those of Suzuki *et al.*(1991) who reported an increase in seed yield with nitrogen application. Raj Singh and Khan (2002) found that application of 20 kg N and 40 kg P $ha^{-1}$ increased seed yield of clusterbean under rainfed condition.Burman *et al*. (2007) found that application of nitrogen (20 kg $ha^{-1}$) in association with P (20 kg $ha^{-1}$) significantly enhanced the seed yield of clusterbean under rainfed condition of Jodhpur in a two years study.Under moisture stress condition plant response to applied fertilizers is frequently reduced (Bradford and Hsiao, 1992). It is agreed that plant response to applied nutrients by rainfed crops is not assured and sometimes may not be profitable unless proper soil moisture is available. However, the degree of yield response varied with rainfall pattern, intensity of drought, native soil fertility and crop species.Application of P was observed to enhance drought tolerance under different intensities of water stress in clusterbean genotypes (Burman *et al*., 2009). P nutrition mellowed adverse effects of water stress on leaf metabolites, NR activity and photosynthesis leading to improved seed yields.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).Higher guar yield with application of nitrogen, as noticed in the present investigation confirms the documented evidence of Bamboo and Rana (1995), Patel *et al*., (2005), Sharma and Nehara (2004) and Rathore*et al*., (2007).The studies of Vyas *et al*. (2001) also indicatedthat seed yield of arid legumesincreased with increasing K levels even under low levels of soil moisture availability. There was no significant difference in mean haulm yield due to differentfertilizermanagement practices. However, the highest mean haulm yield was obtained with 20 kg N $ha^{-1}$treatment.

**Economics**

Gross returns, net returns and B:C ratio for differentfertilizer management practices were calculated and presented in Table 6.Gross returns, net returns and B:C ratio were not significantly influenced by various fertilizer management practices. But however, higher gross returns were realized with 20 kg N + 20 kg P + 20 kg K+ 3 kg Bo $ha^{-1}$followed by 20 kg N $ha^{-1}$ treatment.Higher

**Table 1: Rainfall and rainy days during crop growth period**

| Parameter | 2013-14 | 2014-15 | 2015-16 |
|---|---|---|---|
| Date of sowing | 12.07.2013 | 16.07.2014 | 19.06.2015 |
| Date of harvesting | 04.10.2013 | 10.10.2014 | 11.09.2015 |
| Crop duration (days) | 85 | 86 | 84 |
| Normal annual rainfall (mm) | 573 | 570 | 591 |
| Actual annual rainfall (mm) | 431.8 | 375.2 | 641 |
| Rainfall during crop period (mm) | 328.4 | 160.6 | 212.6 |
| Number of rainy days during the year | 23 | 26 | 44 |
| Number of rainy days during crop period | 11 | 10 | 14 |

**Table 2: Weather during crop growth period of clusterbean during 2013-14**

| Phenophase | Number of days | Maximum temperature ($^0$C) | Minimum temperature ($^0$C) | Rainfall (mm) | Rainy days |
|---|---|---|---|---|---|
| Sowing to emergence | 3 | 31.1 | 22.7 | 40.8 | 1 |
| Emergence to flowering | 22 | 32.4 | 23.2 | 8.6 | 1 |
| Flowering to pod initiation | 12 | 32.1 | 23.0 | 10.4 | 1 |
| Pod initiation to pod development | 9 | 33.6 | 22.9 | 1.6 | 0 |
| Pod development to maturity | 39 | 32.1 | 22.2 | 267.1 | 8 |

**Table 3: Weather during crop growth period of clusterbean during 2014-15**

| Phenophase | Number of days | Maximum temperature ($^0$C) | Minimum temperature ($^0$C) | Rainfall (mm) | Rainy days |
|---|---|---|---|---|---|
| Sowing to emergence | 4 | 33.4 | 23.6 | 16 | 1 |
| Emergence to flowering | 21 | 33.5 | 23.5 | 4.0 | 0 |
| Flowering to pod initiation | 10 | 34.3 | 23.3 | 5.4 | 1 |
| Pod initiation to pod development | 10 | 33.0 | 22.4 | 84 | 5 |
| Pod development to maturity | 41 | 33.3 | 22.4 | 51.2 | 3 |

**Table 4: Weather during crop growth period of clusterbean during 2015-16**

| Phenophase | Number of days | Maximum temperature ($^0$C) | Minimum temperature ($^0$C) | Rainfall (mm) | Rainy days |
|---|---|---|---|---|---|
| Sowing to emergence | 3 | 30.6 | 23.5 | 42.8 | 1 |
| Emergence to flowering | 20 | 35.9 | 24.8 | 2.0 | 0 |
| Flowering to pod initiation | 11 | 35.1 | 24.8 | 10.6 | 1 |
| Pod initiation to pod development | 11 | 35.4 | 24.3 | 27.6 | 1 |
| Pod development to maturity | 39 | 34.3 | 23.7 | 129.6 | 11 |

**Table 5: Plant height and yield attributes of clusterbean as influenced by fertilizer management practices in rainfed alfisols (Mean of 3 years data)**

| Treatments | Plant height (cm) | No. pods per plant | No. seeds per pod | Test weight (g) |
|---|---|---|---|---|
| $T_1$: Control (No N, P and K) | 33.5 | 20.2 | 6.3 | 32.0 |
| $T_2$: 20 kg N $ha^{-1}$ | 34.5 | 19.1 | 6.4 | 32.7 |
| $T_3$: 20 kg P $ha^{-1}$ | 34.4 | 21.8 | 6.4 | 32.6 |
| $T_4$: 20 kg K $ha^{-1}$ | 35.8 | 23.1 | 6.4 | 34.0 |
| $T_5$: 20 kg N + 20 kg P $ha^{-1}$ | 34.5 | 22.2 | 6.9 | 32.5 |
| $T_6$: 20 kg P + 20 kg K $ha^{-1}$ | 33.9 | 21.4 | 6.3 | 33.2 |
| $T_7$: 20 kg N + 20 kg K $ha^{-1}$ | 31.9 | 20.0 | 6.5 | 33.1 |
| $T_8$: 20 kg N + 20 kg P ha-1+ 20 kg K $ha^{-1}$ | 34.0 | 22.4 | 6.5 | 32.0 |
| $T_9$: T8 + 25 kg Zn So4 $ha^{-1}$ | 34.8 | 20.4 | 6.5 | 34.1 |
| $T_{10}$: T8 + 3 kg Bo $ha^{-1}$ | 34.6 | 20.3 | 6.3 | 33.6 |
| $T_{11}$: T8 + 25 kg Zn So4 $ha^{-1}$ + 3 kg Bo $ha^{-1}$ | 33.9 | 21.3 | 6.5 | 33.6 |
| S.Em ± | 1.45 | 2.01 | 0.16 | 1.07 |
| CD at 5% | NS | NS | NS | NS |

**Table 6: Yield and economics of clusterbean as influenced by fertilizer management practices in rainfed alfisols (Mean of 3 years data)**

| Treatments | Seed yield (kg/ha) | Haulm yield (kg/ha) | Gross Returns (Rs/ha) | Net Returns (Rs/ha) | B : C ratio |
|---|---|---|---|---|---|
| $T_1$: Control (No N, P and K) | 633 | 1315 | 20644 | 11344 | 1.22 |
| $T_2$: 20 kg N $ha^{-1}$ | 689 | 1555 | 22484 | 12926 | 1.35 |
| $T_3$: 20 kg P $ha^{-1}$ | 637 | 1421 | 20597 | 10322 | 1.00 |
| $T_4$: 20 kg K $ha^{-1}$ | 673 | 1374 | 21885 | 12014 | 1.22 |
| $T_5$: 20 kg N + 20 kg P $ha^{-1}$ | 616 | 1350 | 19912 | 9379 | 0.89 |
| $T_6$: 20 kg P + 20 kg K $ha^{-1}$ | 639 | 1245 | 20662 | 9816 | 0.90 |
| $T_7$: 20 kg N + 20 kg K $ha^{-1}$ | 669 | 1417 | 21501 | 11371 | 1.12 |
| $T_8$: 20 kg N + 20 kg P ha-1+ 20 kg K $ha^{-1}$ | 648 | 1215 | 20841 | 9737 | 0.88 |
| $T_9$: T8 + 25 kg Zn So4 $ha^{-1}$ | 654 | 1326 | 21022 | 8467 | 0.67 |
| $T_{10}$: T8 + 3 kg Bo $ha^{-1}$ | 713 | 1387 | 23139 | 11284 | 0.95 |
| $T_{11}$: T8 + 25 kg Zn So4 $ha^{-1}$ + 3 kg Bo $ha^{-1}$ | 625 | 1372 | 20224 | 7219 | 0.56 |
| S.Em ± | 51.4 | 95 | - | - | - |
| CD at 5% | NS | NS | - | - | - |

**Table 7: Correlation coefficient between yield attributes and yield of clusterbean as influenced by fertilizer management practices in rainfed alfisols during 2013-14**

| Parameter yield | Plant height (cm) | No. pods per plant | No. seeds per pod | Test weight (g) | Seed yield (kg/ha) | Haulm (kg/ha) |
|---|---|---|---|---|---|---|
| Plant height (cm) | 1 | | | | | |
| No. pods per plant | 0.167 | 1 | | | | |
| No. seeds per pod | 0.118 | 0.440 | 1 | | | |
| Test weight (g) | -0.168 | -0.708 | -0.702 | 1 | | |
| Seed yield (kg/ha) | 0.338 | 0.234 | 0.516 | -0.424 | 1 | |
| Haulm yield (kg/ha) | 0.346 | 0.071 | 0.651 | -0.501 | 0.739 | 1 |

net returns and B:C ratio were obtained with 20 kg N $ha^{-1}$ followed by 20 kg K $ha^{-1}$ treatment and control.

**Correlation between yield attributes and yield**

There was no significant correlation between yield attributes and yield during three years of experimentation (Table 7, 8, 9and 10). However in 2013-14, seed yield and haulm yield were positively correlated with plant height and number of seeds per pod. Number of seeds per pod was positively correlated with number of pods per plant, seed yield was positively correlated with number of pods per plant and haulm yield. During 2014-15, number of pods per plant, number of seeds per pod and seed yield were positively correlated with plant height. Number of pods per plant were positively correlated with number of seeds per pod. Seed yield was positively correlated with haulm yield. In 2015-16, number of pods per plant, test weight and seed yield were positively correlated with plant height. Seed yield was positively correlated with number of pods per plant. Number of seeds per pod were positively correlated with haulm yield. In pooled data, number of pods per plant were positively correlated with plant height. Haulm yield and number of seeds per pod were positively correlated with number of pods per plant. Seed yield and haulm yield were positively correlated with number of seeds per pod. Test weight was positively correlated with seed yield. Seed yield was positively correlated with haulm yield.

From the above studies, it is concluded that application of 20 kg N $ha^{-1}$ can be recommended to scarce rainfall zone of Andhra Pradesh of for maximization of profits in clusterbean crop.

## LITERATURE CITED

**Ayub M, Nadeem M A, Naeem M, Tahir M, Tariq M and Ahmad W 2012** Effect of different levels of P and K on growth, forage yield and quality of clusterbean. *The Journal of Animal and Plant Sciences,* 22 (2):479-483.

**Bradford K J and Hsiao TC1992** Physiologiacl responses to moderate water stress. In: Lange OL, Nobel PS, Osmand CB (Eds) Physiological plant ecology II water relations and carbon assimilation, springer-verlag, New York pp.263-324.

**Bamboo R and Rana N S 1995** Nutrient uptake and yield of clusterbean as influenced by nitrogen, phosphorus and seed rate. Indian Journal of Agronom, 40 (3):482-485.

**Burman U, Garg B K and Kathaju 2007** Interactive effects of phosphorus, nitrogen and thiourea on clusterbean under rainfed conditions of the Indian arid zone. *Journal of plant nutrition and soil science,* 170:803-810.

**Burman U, Garg B K and Kathaju 2009** Effect of phosphorus application on clusterbean under different intensities of water stress. *Journal of plant nutrition*, 32:668-680.

**Garg B K and Uday Burmen 2011** Physiological basis of yield improvement of arid zone crops through nutrient management. Plant stress2011 Global Science Books.

**Nandwal A, Dabas Bhati Sand Yadav B D 1990** Zinc effect on nitrogen fixation and clusterbean yield. Annals of Aridzone. 29:99-103.

**Pathak R, Singh M and Henry A 2009** Genetic divergence in cluster bean (Cyamopsis*tetragonoloba*(L.) Taub) for seed yield and gum content under rainfed conditions. *Indian Journal of Agricultural Sciences,* 79(7), 559-561.

**Patel I C, Patel M M, Patel A G and Tikka S B S 2005** Response of kharif guar to fertilizers and row spacing under rainfed conditions. *Indian Journal of Pulses Research*, 18 (2): 246-247.

**Raj Singh and khan 2002** Effect of integrated nutrient management in *clusterbean*. *Indian Journal of Agronomy*, 47 (1): 45-51.

**Rathore V S, Singh J P, Soni M L, Yadava N D and Beniwal R K 2007** Effect of nutrient management on growth, productivity and nutrient uptake of clusterbean in arid regions. *Indian Journal of Agricultural Science,* 77 (6):349-353.

**Serraj R, Adu Gyamfi J, Rupela O P and Drevan JJ 2004** Improvement of legumes productivity and rate of symbiotic N fixation in croppingsystems: Overcoming the physiological and agronomic limitations. In: Symbiotic nitrogen fixation: Prospects for enhanced application in tropical agriculture. Oxford & IBH publishing Co Pvt. Ltd. New Delhi pp.68.

**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.

**Singh N P, ChoudharyA K and Chaudhary S P S 2003** Genetic divergence in cluster bean (*Cyamopsistetragonoloba*(L.) Taub). *Indian Journal of Agricultural Sciences*, 73(6), 356-357.

**Singh R V, Chaudhary S P S, Singh J and Singh N P 2005** Genetic divergence in cluster bean (*Cyamopsistetragonoloba*(L.) Taub). *J. Arid Legumes*, 2(1):102-105.

**Sharma S K and Nehra K C 2004** Effect of different varieties and fertilizer levels on yield and yield attributing characters of guar. National symposium on Arid Legumes for sustainable Agriculture and Trade 51.

**Suzuki M, Miyakawa H and Sato Y 1991** Measures against decreasing yields in continuously cropped soyabean. *The crop science*, Japan, 34:65.

**Undersander D J, Putnam D H, Kaminski A R, KellingK A, Doll J D, Oplinger E Sand Gunsolus J L 1991** Guar. In: Alternative Field Crops Manual.

**Vyas S P, Garg B K, Kathaju S, Lahiri 2001** Influence of potassium on water relationphotosynthesis, nitrogen metabolism and yield of clusterbean under soil moisture stress. *Indian Journal of plant physiology,* 6 (New series), 30-37.

(Received on 19.06.2017 and revised on 24.04.2018)