International Journal of

Agricultural Research

ISSN 1816-4897

Academic
Journals Inc.

www.academicjournals.com

International Journal of Agricultural Research 2 (6): 537-544, 2007
ISSN 1816-4897

Agronomic Evaluation of Promising Genotypes of Mung Bean under Hyper Arid Conditions of Indian Thar Desert

Nishi Mathur, Joginder Singh, Sachendra Bohra, Avinash Bohra and Anil Vyas
Department of Botany, Microbial Biotechnology and Biofertilizer Laboratory,
J.N.V. University, Jodhpur, India-342003

Abstract: An experiment in factorial RBD was conducted during Kharif 2005 at Gangana village, Jodhpur with 4 improved genotypes (RMG-62, RMG-268, RMG-492 and K-851), 2 fertility levels (10+20 and 20+40 kg N+P_2O_5 ha^{-1}) and 2 row spacing (30 and 45 cm, respectively). The genotypes showed significant variation in plant height, branches per plant, total biomass per plant; pods/plant, seeds/pod, 100 seed weight straw yield and seed yield. Genotype RMG-492 recorded significantly highest plant height, pods/plant, seeds/pod, total biomass per plant and thus straw and seed yield than other genotypes. It was followed by K-851. Increase in fertility level from 10+20 to 20+40 kg N+P_2O_5 ha^{-1} significantly enhanced mean plant height (24.4%), branches/plant (22.7%), pods/plant (25.6%), seeds/pod (21.3%), 100 seed weight (7.3%), biomass per plant (15.5%) and ultimately straw and grain yield (9.8 and 24.4%), respectively. Similarly, increase in row spacing from 30 to 45 cm significantly enhanced all important plant growth and yield attributes viz., plant height (21.6%), branches per plant (28.8%), seeds/pod (11.9%), 100 seed weight (15.7%) and biomass per plant (13.4%). However, the overall seed and straw yield significantly reduced by 10.8 and 20.9%, respectively at wider spacing of 45 cm. It shows that the increased in various plant growth and yield attributes could not make up for reduction in plant population in wider row spacing under hyper arid conditions. The overall interaction studies among genotypes, fertility levels and row spacing revealed significantly higher grain and straw yield of RMG-492 followed by K-851 with higher fertility level of 20+40 kg N+ P_2O_5 ha^{-1} at narrower row spacing of 30 cm.

Key words: Mung bean, genotypes, fertility levels, row spacing, hyper arid

---

INTRODUCTION

Mung bean (*Vigna radiata* L. Wilczek) is known for its hardiness against harsh climatic and low water availability conditions. However, generations of selection pressure mostly for adaptation to stress environment has eroded genes for higher production (Chopra and Sharma, 1985) and thus, its average yield is far below (381 kg ha^{-1}) (Ali Masood *et al*., 2002). Harsher situation of hyper arid Thar region in western Rajasthan leads to further lower yields or even complete crop failure (Faroda and Singh, 2003). In spite of all these, farmers of this region have no choice except to grow arid legume crops like mung bean with hope of some returns. The farmers of the region thus, compelled to believe in low input-low risk-low yield concept. Though, arid legume crops like mung bean are quite capable of sustain yield under harsh conditions due to physiological and morphological characteristics but need urgent attention for bringing the quantum jump in the productivity (Faroda and Singh, 2003).

In recent times several mung bean genotypes have been identified due to integrated efforts under All India Coordinated Research Project in Arid Legumes and many were released for commercial

---

Corresponding Author: Anil Vyas, Department of Botany, Microbial Biotechnology and Biofertilizer Laboratory, J.N.V. University, Jodhpur, India-342003 Tel: +91-09414128040

cultivation. These genotypes mature in 75-90 days (eg., Pusa 9531, RMG-62, K-851) and even 60-65 days (e.g., RMG-344, RMG-492, RMG-268) and produces higher grain and straw yields in comparison to traditional land races/varieties which matures in 90-120 days or even more (Ali Masood *et al*., 2002; Dwivedi, 2006). These new genotypes are mainly erect or semi erect type with synchronized maturity period and responsive to agronomic management.

Among agronomic management, optimum supply of nutrients is of great importance considering the low fertility status of the soils and poor yield of mung bean. Singh and Tripathi (2005) found that the application of N and P has significant response on increasing seed and straw yield of mung bean.

Besides improved varieties and optimum fertilizer rates, row spacing also plays vital role in establishment of optimum plant population and seed yield. Most of the improved genotypes are short to medium duration and erect to semi erect type. These genotypes can grow optimally even at narrow spacing. In hyper arid condition effect of narrow spacing can be explained by the fact that close canopy may intercept a large percentage of solar radiation, thereby increasing photosynthesis and reducing soil evaporation losses (Patel *et al*., 1985).

Jodhpur is situated in the west of Rajasthan and is the gate way of Indian Thar desert. The normal rainfall of the district is 266 mm at the eastern most part and decreases to less than 100 mm in western end. The number of rainy days varies between 6 to 18 days. Often the duration between two rain events is more than one month. Addition to this high temperature and wind speed results into excessively high rate of evapotranspiration. The soils become dry upto 50 cm depth with in 15-25 days depending upon wind speed and insolation. Under such circumstances genotypes with fast root growth would withstand better than slow root growth types. Further, as most roots will penetrate deeper in soil for extraction of moisture, there will be comparatively lesser competition among roots in upper 50 cm soil profile. Besides this, over all growth of the above ground part will be restricted due to translocation of sufficient quantity of photosynthate for initial quick root growth. Therefore, narrow spacing may be beneficial under Jaisalmer situation. Sowing at closer spacing can act as a micro windbreak and help to minimize the negative effect of high wind speed. Poor fertility status (Narain and Kumar, 2003) and poor microbial population (Rao and Ventaketswaralu, 1983) in these soils results into still lower availability of nutrients for successful crop cultivation. Thus, application of optimum fertilizer doses with narrow spacing can enhance the nutrient uptake efficiency.

Keeping above facts and hypothesis in mind, present investigation was undertaken to investigate the response of mung bean genotypes to fertility levels (nitrogen and phosphorous fertilization) and row spacing which may help the farmers in increasing mung bean yield in hyper arid areas of Rajasthan.

MATERIALS AND METHODS

The Climate

Year 2005 was a below normal year. During the year 140.9 mm total rainfall occurred which was just 60.5% of the normal rainfall of the area. Since 1960 on an average only once in six years rainfall less than this magnitude was recorded at Gangana village. The first monsoon shower of 35.0 mm was recorded on August 1st week and afterward two showers of 4.3 and 22.3 mm were recorded on August 12 and 16, respectively. There was a prolong dry period till September 20 (12.2 mm). The monsoon withdrew from the area after. October 8 (9.3 mm). In total 83.1 mm rainfall was received during the season. The mean monthly temperature and wind speed varied between 39.2 (July) to 32.4°C (October) and 33.2 (August) to 5.1 km h^{-1} (October) wind speed, respectively. The overall profiles of rainfall pattern, temperature, wind speed and evapotranspiration reveals that there was sufficient moisture for 65 days with intermittent severe moisture stress period of 8 and 12 days at 48 days after sowing and pod filling stages, respectively.

Table 1: Physio-chemical properties of the soils of the experimental site

Horizon	Depth (cm)	Particle size distribution Sand (%)	Clay (%)	Texture	$CaCO_3$	pH	ECe (dSm^{-1})	Organic carbon (%)	CEC (cmol (+P)/kg)
Mixed, hyperthermic, calcareous family of typic torripsamments									
Ap	0-20	75.4	6.0	Loamy sand	5.6	8.5	0.7	0.14	3.7
C1	20-50	88.5	6.9	Loamy sand	4.2	8.7	0.6	0.07	2.9
C2	50-105	89.4	6.6	Loamy sand	5.4	8.8	0.5	0.08	2.5
C2	105-140	86.4	6.5	Loamy sand	6.5	8.6	0.4	0.09	2.6

The Soils

The experiment was laid out in almost level (0-1% slope) aeolian plain. The soils of the sites were classified as deep, mixed, hyperthermic, calcareous family of Typic Torripsamments (Table 1). The soils were low in organic carbon (0.14 %) and available) N content (227 kg $KMnO_4$-N ha^{-1}), medium in P (18 kg P ha^{-1}) and K content (148 kg K ha^{-1}).

These almost level, well drained, very deep sandy loam soils with 4.2 to 6.5% free $CaCO_3$ content provide sufficient soil volume and condition for *in situ* rain water conservation and penetration of mung bean roots deeper into sub surface soils. However, alkaline condition of the soils (pH > 8.0) imposed slight limitation for successful rainfed cultivation of mung bean.

The Experimental Details

A field experiment was conducted during Kharif, 2005 at Gangana village, Jodhpur to asses the performance of mung bean genotypes to row spacing and fertility levels. Four mung bean genotypes RMG-62, RMG-268, RMG-492 and K-851 were tested at two fertility levels (10 kg N + 20 kg P_2O_5 and 20 kg N + 40 kg P_2O_5 ha^{-1}) and two row spacings (30 and 45 cm) in factorial randomized block design with three replications.

Basal application of nitrogen and phosphorous was done in rows through urea and DAP before sowing of seed as per treatment. The crop was sown on July last week, 2005 one day after good shower of rains (35.0 mm). The field was kept free from insect-pest and diseases by adopting proper plant protection measures and free from weeds by hoeing and weeding.

At maturity 5 plants per plot were randomly harvested from second and third rows from the western side of the each plot to estimate mean plant height (cm), branches per plant, pods per plant, seeds per pods, biological weight per plant (g) and 100 seed weight (g). The net plot was demarcated and harvested to estimate seed and biological yield (kg ha^{-1}). Analysis of variance (ANOVA) technique was used to compare the means of different growth and yield attributes to draw logical conclusions.

RESULTS AND DISCUSSION

Effect of Genotypes on Growth Attributes

Genotypes showed significant variation in all the growth attributes under study (Table 2). RMG-268 produced significantly lower plant height, branches per plant, weight of seed, straw and total biomass per plant than rest of the genotypes. RMG-492 recorded significantly higher plant height than K-851 and RMG-268, but remained at par with RMG-62. However, RMG-62 produced significantly more branches per plant than rest of the genotypes except K-851. Similar to plant height, total biomass per plant was higher in RMG-492 than rest of the genotypes but remained statistically at par with K-851. Results comparable to total biomass per plant were also found for seed and straw weight per plant.

Successive rains at shorter duration during initial growth stage gave a good start to express their genetic potential. However, slight to moderate moisture stress period at grand growth period beyond August 28 forced mung bean genotypes to shift on conservative water use strategy depending upon

Table 2: Growth attribute of mung bean genotypes at varying fertility levels and row spacing

Treatments	Plant height (cm)	Branch/plant	Seed weight/ plant (g)	Straw weight/ plant (g)	Total dry matter/plant (g)
Genotypes					
RMG-62	14.3	4.0	0.59	2.94	3.18
RMG-268	12.1	2.6	0.42	2.51	2.76
RMG-492	15.2	3.6	0.70	3.45	3.75
K-851	14.9	3.7	0.65	3.01	3.39
LSD (p = 0.05)	1.0	0.6	0.05	0.29	0.29
Fertility levels (kg ha^{-1})					
10 kg N+ 20 kg P_2O_5	13.8	3.0	0.48	2.65	3.08
20 kg N+ 40 kg P_2O_5	15.9	3.6	0.62	2.98	3.62
LSD (p = 0.05)	0.8	0.5	0.03	0.20	0.22
Row spacing (cm)					
30	12.8	3.9	0.52	2.68	3.28
45	14.2	3.7	0.50	2.90	3.52
LSD (p = 0.05)	0.5	0.5	0.02	0.19	0.22

their drought tolerance capacity. Under such conditions, genotypes with deeper root systems will only be able to face the droughts efficiently (Ali Masood *et al.*, 2002). Root studies at harvest showed more proportion of roots (by count) of RMG-492 beyond 75 cm soil profile. It was followed by K-851. However, RMG-268 had lowest proportion of roots beyond 75 cm.

Effect of Fertility Levels on Growth Attributes

Increase in fertility level from 10 kg N + 20 kg P_2O_5 to 20 kg N + 40 kg P_2O_5 ha^{-1} significantly increased all growth attributes studied (Table 2). On an average, higher fertility level of 20 kg N + 40 kg P_2O_5 ha^{-1} increased plant height, branches per plant, weight of seed, straw and total biomass by 24.4, 29.9, 23.4, 16.0 and 18.0%, respectively in comparison to lower fertility level of 10 kg N + 20 kg P_2O_5 ha^{-1}. Lesser distribution of roots in upper soil layer due to unavailability of moisture might restricted the availability of nutrients at lower fertility level.

Effect of Row Spacing on Growth Attributes

Wider spacing of 45 cm significantly increased plant height, branches per plant, weight of seed, straw and total biomass per plant in comparison to narrow spacing of 30 cm by 12.8, 3.9, 0.52, 2.68 and 3.28% than narrow spacing (Table 2). Lower competition for moisture, nutrients, light and space might have attributed to higher growth at wider spacing.

Effect of Genotypes on Yield Attributes

Genotypes showed significant variation in yield attributes (Table 3). Among the genotype pods per plant was significantly highest in RMG-492 while lowest in RMG-268. Seeds per pod was also lowest in RMG-268 than rest of the genotypes, but the attributes was at par in other genotypes. However, 100 seed weight was statistically highest in K-851. It was followed by RMG-492 and RMG-268. Genotype RMG-62 has lightest seed. Larger biological frame on which more flowers and eventually more pods can be developed resulted into significantly higher yield attributes in RMG-492 followed by K-851.

Effect of Fertility Levels on Yield Attributes

Increase in fertility levels from 10 kg N + 20 kg P_2O_5 to 20 kg N + 40 kg P_2O_5 ha^{-1} significantly enhanced the yield attributes (Table 3). With application of 20 kg N + 40 kg P_2O_5 ha^{-1} number of pods per plant seeds per pod and 100 seed weight increased by 25.6, 21.3 and 7.3%, respectively. Nitrogen is required in large amount in plant tissues, since it is a component of critical plant constituents including proteins, amino acid, nucleotides, nucleic acid and chlorophyll (Grant and Bailey, 1993).

Table 3: Yield attributes and yield of mung bean genotypes at varying fertility levels and row spacing

Treatments	Pods/plant	Seeds/pod	100 seed weight (g)	Biological yield (kg ha^{-1})	Harvest index	Seed yield (kg ha^{-1})
Genotypes						
RMG-62	15.6	3.5	2.68	378	28.2	92
RMG-268	12.5	2.9	3.03	235	35.1	75
RMG-492	24.6	4.0	3.12	550	26.4	130
K-851	19.3	3.7	3.30	638	19.8	112
LSD (p = 0.05)	1.4	0.15	0.12	62	4.8	14
Fertility levels (kg ha^{-1})						
10 kg N+ 20 kg P_2O_5	16.0	3.8	3.20	402	28.2	96
20 kg N+ 40 kg P_2O_5	20.3	4.6	3.40	488	26.7	108
LSD (p = 0.05)	0.9	0.2	0.09	44	NS	9
Row spacing (cm)						
30	14.3	4.4	2.29	490	25.6	114
45	13.5	4.8	3.42	392	28.8	98
LSD (p = 0.05)	0.9	0.3	0.08	42	NS	9

Most of the leguminous crops fix N from atmosphere and thus, does not respond to higher doses of nitrogen application. However, very high soil temperature (> 45°C upto 20 cm soil depth), negligible moisture and organic carbon content make the soil environment very unfavourable for nitrogen fixing bacteria under hyper arid region (Gajendiran and Mahadevan, 1990). Addition to this, although soils of the experimental site was medium in phosphorous content, its availability to plants get restricted due to presence of free $CaCO_3$, limited moisture and slightly higher pH (Mengel and Kirkby, 1987). Thus, overall, negligible biological nitrogen fixation and reduced phosphorous availability might have resulted into significantly better response at higher fertility levels.

Effect of Row Spacing on Yield Attributes

Significant effect of change in row spacing on pods/plant, seeds/pod and 100 seed weight was found in hyper arid conditions (Table 3). At wider spacing of 45 cm, seeds per pod and 100 seed weight recorded an increase of 11.9 and 15.7%, respectively in comparison to narrow spacing of 30 cm. However, number of pods per plant decreased by 10.8%. Comparatively higher wind speed and limited moisture availability during pre flowering and flowering stage resulted into more dropping of flowers at wider spacing. While windward rows at narrow spacing might have acted as micro windbreaks for leeward side rows and thus resulted into lesser flower droppings. The lesser number of flowers and thus lesser number of pods pet plant at wider spacing eventually produced fewer sinks. It resulted into significantly more seed per pod and 100 seed weight.

Effect of Genotypes on Yield

Genotypes showed significant variation in biological yield, harvest index and thus, seed yield (Table 3). Among genotypes the biological yield significantly varied in a sequence of K-851>RMG-492> RMG-62> RMG-268 while harvest index was ranked as RMG-268> RMG-62=RMG-492>K-851. The product of biological yield and harvest index resulted in significant variation in seed yield as - RMG-492>K-851>RMG-62>RMG-268. Overall larger biological frame (Table 2), efficient photosynthate translocation capacity (HI) and better yield attributes of RMG-492 resulted into higher biological and seed yield. Although efficient translocation of food material resulted into significantly higher harvest index of RMG-268 but overall poor growth indicates its less suitability for the region.

Effect of Fertility Level on Yield

Fertility level of 20 kg N + 40 kg P_2O_5 ha^{-1} in comparison to 10 kg N + 20 kg P_2O_5 ha^{-1} significantly increase biological and seed yield while harvest index remained statistically at par in both fertility levels (Table 3). There was an increase of 24.6% in biological yield and 9.9% in seed yield by increasing fertility levels from 10 kg N + 20 kg P_2O_5 to 20 kg N + 40 kg P_2O_5 ha^{-1}. Better growth and higher yield attributes at higher fertility level resulted into higher biological and seed yield in comparison to lower fertility level. Non-significant change in harvest index indicates no change in photosynthate translocation activity. It may be because pod itself acts as a major site for the photosynthetic activity responsible for seed dry matter production and thus, total biological frame vis-a-vis leaf area has only little contribution towards pod filling (Allen and Morgen, 1972).

Effect of Row Spacing on Yield

N arrow spacing of 30 cm produced significantly higher biological and seed yield in comparison to wider spacing, whereas, harvest index remained non-significant (Table 3). Biological yield at wider spacing was reduced by 20.5% in comparison to narrow spacing of 30 cm. The reduction in grain yield was however, just 10.8%. The mean yield attributes per plant were increased by just 15.8% by increasing spacing from 30 to 45 cm, while the total plant population per hectare reduced by 33.8%. It shows that the increase in various plant growth and yield attributes could not makeup for reduction in plant population at wider spacing under hyper arid conditions.

Effect of Genotypes × Fertility Level on Various Attributes

Interaction between genotypes and fertility levels significantly influenced pods per plant, seeds per pod, 100 seed weight, seed weight per plant, harvest index and biological yield (Table 2). Increase in fertility level significantly increased pods per plant, seeds per pod, 100 seed weight and seed weight per plant in all the genotypes except, pods per plant, seeds per pod and seed weight per plant in RMG-268 and 100 seed weight in RMG-268 and K-851. With the increase in fertility the harvest index increased significantly in RMG-62 but it remained at par in other genotypes. Overall, RMG-492 at higher fertility level of 20 kg N + 40 kg P_2O_5 ha^{-1} produced significantly maximum pods per plant. The number of seeds per pod was significantly highest in RMG-62 at higher fertility but remained at par with RMG-492 and K-851 at same fertility levels. Total seed weight per plant was significantly highest in RMG-492 followed by K-851 at higher fertility level. K-851 at higher fertility level recorded significantly higher biological yield than any other combination. It was followed by RMG-492 at same fertility level.

Effect of Genotypes × Row Spacing on Various Attributes

Interaction between genotypes and row spacing significantly Influenced seeds per pod, 100 seed weight, harvest index and biological yield (Table 2). The number of seeds per pod significantly increased in all genotypes except RMG-62 when row spacing was increased to 45 from 30 cm. The seeds per pod in RMG-62 remained statistically at par in both spacing. At 30 cm spacing RMG-268 recorded significantly lower seeds per pod than rest of the genotypes. Seeds per pod in rest genotypes remained statistically at par to each other. However, at wider spacing seeds per pod value in RMG-268 was significantly lower than RMG-492 and K-851. In general, wider spacing of 45 cm significantly increased 100 seed weight in all the genotypes in comparison to narrow spacing. Overall, maximum 100 seed weight of 3.66 g was recorded in K-851 at wider spacing. At narrow spacing of 30 cm K-851 followed by RMG-492 recorded significantly higher 100 seed weight than rest two genotypes while at wider spacing K-851 had significantly higher 100 seed weight than rest three genotypes and it was followed by RMG-268 and RMG-492.

Change in row spacing from 30 to 45 cm, significantly increased the harvest index value in RMG-62, while it decreased the value in RMG-492. No significant variation was recorded in rest two genotypes. At narrow spacing RMG-268 and RMG-492 produced significantly higher harvest index than rest two while at wider spacing of 45 cm RMG-268 and RMG-62 recorded significantly higher harvest index.

The increase in row spacing decreased total biological yield in RMG-62 and K-851, remain at par in RMG-268 but increased in RMG-492. At 30 cm row spacing genotypes K-851 produced significantly higher biological yield than rest. It was followed by RMG-492 and RMG-62, which were at par with each other by K-851 produced significantly higher biological yield than rest two genotypes.

Effect of Fertility Levels × Row Spacing on Various Attributes

Significant impact of interaction between fertility level and row spacing was found in pods per plant, 100 seed weight, harvest index and biological yield of mung bean (Table 3). The increase in fertility level from 10 kg N + 20 kg P_2O_5 to 20 kg N + 40 kg P_2O_5 ha^{-1} significantly increased pods per plant at both spacing. Contrary to it at higher fertility level pods per plant significantly decreased by increasing row spacing but the decrease remains statistically at par with lower fertility level. The increase in row spacing as well as fertility levels significantly increased the 100 seed weight. However, at narrow spacing it remained non- significant with increase in fertility level. The increase in fertility level significantly decreased the harvest index at narrow spacing while it increased significantly at wider spacing. The harvest index significantly increased with increase in row spacing to 45 cm at higher fertility level while it remained at par at lower fertility level. Biological yield of mung bean significantly increased with increase in fertility levels at narrow spacing of 30 cm but the increase remain non-significant at wider spacing. Contrary to it increase in row spacing decreased the biological yield, however, the difference was significant at higher fertility level of 20 kg N + 40 kg P_2O_5 ha^{-1} only.

CONCLUSIONS

The study shows strong interaction between various agronomic factors under hyper arid situation. Variety RMG-492 followed by K-851, higher fertility levels of 20 kg N + 40 kg P_2O_5 ha^{-1}, narrow row spacing of 30 cm appears suitable to enhance and stabilize the fluctuating productivity of mung bean in the region. The study further suggested assessment of important agronomic parameters is essential for recommendation of agro-techniques for a crop in marginal situation of hyper arid for resource optimization.

REFERENCES

Ali Masood, Ganeshmurthy and C.H. Rao Srinivasa, 2002. Role of plant nutrient management in pulse production. Fertilizer News, 47: 83-90.

Allen, E.J. and D.C. Morgen, 1972. A quantitative analysis of the effects of nitrogen on the growth development and yield, 78: 315-324.

Chopra, V.L. and R.P. Sharma, 1985. Induced Mutations in Crop Improvement. In: Genetic Manipulation for Crop Improvement. Chopra, V.L. (Eds.), Oxford and IBH Publishing Co. New Delhi, pp: 23-48.

Dwivedi, N.K., 2006. Germplasm characterization in indigenous green gram (*Vigna radiata* L. Wilczek) from arid and semi-arid region, India. J. Arid Legumes, 3: 55-59.

Faroda, A.S. and Singh Raj, 2003. Crop Production Strategies for Arid Legumes with Remunerative Efforts and Cost. In: Advances in Arid Legumes Research Henry, A., D. Kumar and N.B. Singh (Eds.), Indian Arid Legumes Society, Jodhpur and Scientific Publishers (India) Jodhpur, pp: 161-171.

Gajendiran, N. and A. Mahadevan, 1990. Microbiology of Desert Soil. In: Ecology and Vegetation of Indian Desert. David N. Sen (Ed.), Agrobios (India), Jodhpur, pp: 83-105.

Grant, C.A. and L.D. Bailey, 1993. Fertility management in canola production. Can. J. Plant Sci., 73: 651-670.

Mengel, K. and E.A. Kirk by, 1987. Principles of Plant Nutrition. 4th Edn., International Potash Institute, Bern.

Narain, P. and P. Kumar, 2003. Integrated Nutrient Management Through Arid Legumes in Rajasthan. In: Advances in Arid Legumes Research. Henry, A., D. Kumar and N.B. Singh (Eds.), Indian Arid Legumes Society, Jodhpur and Scientific Publishers (India) Jodhpur, pp: 172-178.

Patel, J.S., M.N. Kistaria, V.P. Paida, M.T. Parmar and J.C. Patel, 1985. Response of rainfed groundnut *Arachis hypogea* (L.) to varying spacing. Indian J. Agron., 30: 468-469.

Rao, A.V. and B. Venkateswaralu, 1983. Microbial ecology of the soils of Indian desert. Agric. Ecol. Environ., 10: 361-369.

Singh, R. and K.P. Tripathi, 2005. Productivity and economics of mung bean (*Vigna radiata* L.) as influenced by varieties and nutrient management. J. Arid Legumes, 2: 223-226.