Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(4): 3311-3315
Received: 22-05-2020
Accepted: 26-06-2020

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Studies on seed quality parameters in cluster bean [*Cymopsis tetragonoloba* (L.) Taub.-guar]

Ankita Kumari, AK Chaurasia and Ajay Kumar Pandey

Abstract
As we know that vegetables have been part of the human diet from time immemorial. Its play an important role in human nutrition. Most are low in fat and calories but are bulky and filling. They supply dietary fiber and are important sources of essential vitamins, minerals and trace element. A large number of underexploited leguminous species have a great potential in contributing nutritious food, feed and forage needs in the tropical countries even though almost half of the population are under malnourished (Singh and Paroda, 1983). Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.] [2n=14], is one of the important underexploited leguminous vegetables belonging to family Fabaceae. It is commonly called by the names *Guar, Chavlikayi, Gorkayi, Khutt, Govar,* in different parts of the country.
The experiment was conducted in post graduate Seed Testing Laboratory, Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) during Rabi season 2019-2020, in order to standardize the best genotype of cluster bean. Sixteen genotype of cluster bean (GR-1, GR-2, GR-3, GR4, GR-5, GR-6, GR-7, GR-8, GR-9, GR10, GR-11, GR-12, GR-13, GR-14, GR-15, & GR-16) were evaluated by screening different seed quality parameters *viz.,* speed of germination, germination percentage, Seed dencity, seedling root length, seedling shoot length, seedling length, seedling fresh weight, seedling dry weight, seed vigour index length, seed vigour index mass, electrical conductivity. It was found that all the genotype showed significance difference with lowest value (GR-1) and the highest germination percent, seedling length, seedling fresh weight, seedling dry weight, vigour indices were observed for GR-15.

Keywords: Cluster bean, different genotype, quality parameters and vigour

Introduction
Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.] [2n=14], is one of the important underexploited leguminous vegetables belonging to family Fabaceae. It is commonly called by the names *Guar, Chavlikayi, Gorkayi, Khutt, Govar, Kothavare* in different parts of the country. It is a drought tolerant, hardy, deep rooted summer annual legume of high social and economic significance and mainly grown for tender vegetable and seed endospermic gum in arid and semi-arid regions of India. The quality of the crop like high adaptation towards erratic rainfall, multiple industrials uses and is important in cropping system for factors such as soil enrichment properties, low input requirement, etc have made the guar one of the most significant crops for farmers in arid areas in India.
The total production of the world is about 10 lakh tons of guar each. Total production of Guar bean in India is estimated to have crossed 2.7 million metric tons during the agricultural year 2013-14 due to good weather conditions in the major Guar producing areas in India. With a moderate production of 250,000 metric tons in Pakistan which is another important guar producing area, the total global production of Guar bean is estimated to have crossed 3 million metric tons during 2013-14. Presently, India accounts for more than three-fourth (or nearly 80 percent) of the total world Guar bean production.
This legume is a precious plant in a crop rotation cycle as it lives in symbiosis with nitrogen-fixing bacteria. Guar has many features for human and animal nutrition, but the most significant use is the gelling agent in its plants (guar gum). Guar gum is an important ingredient in producing food emulsifier, food additive, food thickener, and other gum products. The unique binding, thickening and emulsifying quality of guar gum powder obtained from guar seed has made it a much sought after product in international market.
The dicotyledonous seed of cluster bean from outside to interior consists of three major fractions, *viz.,* the husk or hull (14-17%), endosperm (35-42%) and germ (43-47%). The endosperm fraction of cluster bean seed is rich in galactomannan (16.80 to 30.90%), while the germ and hull portion termed as guar meal obtained after the extraction of gum is rich in protein (28.90-46.00%) and used as animal and poultry feed (Lee *et al.,* 2004 and Rodge, 2008) [17]. Seed of cluster bean with large endosperm contains galactomannan type of gum, which forms a viscous gel even in cold water and has diversified industrial applications *viz.,*

paper, food, cosmetics, mining, petroleum, well drilling, textile and jute, pharmaceuticals (Senapati *et al.*, 2006 and Pathak *et al.*, 2009) [24]. Cluster bean gum has emerged as the most important agro-chemical, which is non-toxic, eco-friendly and Generally Recognized As Safe (GRAS) by Food and Drug Administration (FDA). Guar gum is largely an export oriented commodity with about 75-80 percent of total output being exported from the country. India was the leading exporter of mucilages and thickeners in the world with a share of more than 73 percent in value terms during 2011. Guar now accounts for around 18 percent of India's total agricultural exports (DGCIS & APEDA, 2012-13).

The cluster bean has sufficient nutrient profile especially rich in protein, vitamins A and C content and possesses several medicinal uses in diabetes and control of cholesterol content (Karawya *et al.*, 1994) [15]. Guar is also used as green forage or as green manure crop which can enrich the soil by fixing atmospheric nitrogen (50-60kg/ha) and by addition of organic matter (Lal, 1985) [16]

Cyamopsis tetragonoloba grows upright to a maximum height of up to 2–3 m. It has either basal branching or coarse branching along the stem with a primary single stem. Guar taproots can access soil moisture at low soil depths. The growth, seed yield and quality of seed crop are largely influenced by the nutrient fertility status of the soil apart from genetic potential of the variety. Altering the soil nutrients and fertility status by providing balanced and adequate major nutrients like nitrogen, phosphorus and potassium as per the crop requirement is one of the easiest ways to boost up productivity of cluster bean. Seed development and maturation study is important because the seeds may be harvested to ensure good yield associated with viability, vigour and field performance. At physiological maturity seed achieve desirable characteristics and will have maximum viability and vigour. So it is necessary to harvest crop at physiological maturity to attain desirable quality seeds.

Arora *et al.*, (2011) [8] reported the significant difference among the cluster bean genotypes. The variation for protein content was in the range of 3.80 to 5.88 grams per 100 gram. Girish, (2011) [10] reported wide variability for protein content among the genotypes of cluster bean and it was ranged from 10.15 mg per g (HG-3-100) to 25.85 mg per g (CAZG-06-1) with an overall mean of 16.41 mg per g.ms on green pod weight basis and studied in thirteen cluster bean genotypes for days taken for 50 per cent germination. seed quality parameters *viz.*, 100 seed weight (3.52 g), germination (92.00%), shoot length (16.04 cm), root length (15.87 cm), seedling dry weight (191.44g), seedling vigour index (2919.07) and moisture content (19.11%) were maximum with pods harvested at 100 DAS, while EC was minimum (1.17 dSm-1). These results are conformity with Kalavathi *et al.* and Renugadevi *et al.* in cluster bean.

Gresta F *et al.*, (2013) [11]. Studied the effects of Sowing Times on Seed Yield, Protein and Galactomannans Content of Four Varieties of Guar (*Cyamopsis tetragonoloba* L.) in a Mediterranean Environment. Pathak *et al.* (2011) studied that forty promising genotypes of cluster bean in CAZRI, Jodhpur for crude fibre content and observed significant difference with a range from 4.10 per cent ('HGS 02-1') to 8.0 per cent ('AVKG 73') with an overall mean of 6.30 per cent. Malaghan (2012) reported significant difference among the cluster bean genotypes for fresh pod weight. The weight of ten fresh pods in cluster bean genotypes ranged from 5.50 (HGS-884) to 34.50 g (Pusa Navabahar) with a mean of 11.09 g. Tiwari, A.S., Dabhi, B.M., Chouksey, H. and Singh, A. (2014) [26] studied that the effect of fertility and sulphur levels on quality parameter of summer clusterbean (*Cyamopsis tetragonoloba* L.) under south saurashtra region. Aamir I M (2015) [1] reported that Cluster Bean (*Cyamopsis tetragonoloba* L.) Germination and Seedling Growth as Influenced by Seed Invigoration Techniques.

Method and Materials

The experiment was conducted in post graduate Seed Testing Laboratory, Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture Technology & Sciences, Prayagraj, Uttar Pradesh, India during the year 2019-20 to find out seed quality parameters of cluster bean (*Cyamopsis tetragonoloba* L. Taub.) seeds. The experiment materials for the present study consisted of 16 genotypes of cluster bean received from Directorate of seed and farm, SHUATS, Prayagraj, U.P. were tested for seed quality parameters under controlled conditions. Germination test was conducted in a complete randomized block design with four replications. From each treatment, randomly 100 seeds are selected per replication were put for germination in the sterilized germination paper and was recorded separately for each treatment and replication on final count (14^{th} day). Observation of recorded on germination percentage, root length, shoot length, seedling length, seedling dry weight, seedling fresh weight, vigor index length and vigor index mass. And for speed of germination was conducted in a sterilized sand media. Daily count on the number of germinated seeds was recorded separately for each treatment and replication till the final count (14^{th} day). The tray were incubated at normal light at room temperature and then observation were taken. Seed vigour was tested by conducting paper piercing test, seed density was conducted by using kerosene oil test, Electrical conductivity of seed leachates were observed with EC meter and 1000 seed weight was observed by counting 1000 seed of each genotype separately and weighing there weights separately, these were worked out and the data was stastistically analyzed using ANOVA (Fisher, 1983).

Result and Discussions

Germination percentage ranged from 89 to 45% with the grand mean value of 81.46%. The maximum germination percentage was observed in the genotype GR-15 (89%), followed by the genotypes GR-3(87.25%), whereas the minimum germination percentage was observed in the genotype GR-1(34.5%),followed by the genotypes GR-13(79.25%) and these results are simillarly find out by Adat *et al.*, (2011) [2], Tiwari, A.S., Dabhi, B.M., Chouksey, H. and Singh, A. (2014) [26]. Germination test determine the maximum germination potential of a seed lot, to compare the quality of different seed lots and estimate their field planting value (ISTA, 2004). The germination shows the percentage of normal seedlings, abnormal seedlings and dead seed in a seed lot.

Test weight (1000 seed weight) ranged from 29g to 36.3g with the grand mean value of 32.77g. The maximum test weight was observed in the genotype GR-15 (36.3g), followed by the GR-5 (35.42g), whereas the minimum test weight was observed in the genotype GR-1(29g) followed by the genotypes GR-10(29.32g) and these results are similarly find out by Omkarappa, (1994) [18], Futuless *et al.* (2010) [9], Rozina *et al.* (2007) [22]. Many vegetable species almost invariably produce larger seedling when grown from larger seeds and there was close relationship between seed weight,

seedling vigor, shoot and root length increase in seedling dry weight this may be due to the greater amount of food reserve contained and the greater embryo size or both Wood *et al*. (1977). The higher potential of 1000 seed weight it might due to the initial capacity and more amounts of nutrients available for germination.

Seed density ranged from 36 g/cm³ to 27.2 g/cm³ with the grand mean value of 33.56g/cm³. The maximum seed density was observed in the genotypes GR-15 (36.0g/cm³) followed by the genotypes GR- 5(35.95g/cm³), whereas the minimum seed density observed in the genotype GR-1 (27.2g/cm³), followed by GR-7 (30.45g/cm³),) and these results are similarly find out by Arghya mani *et al*. (2015). Seed density of seed found to be more than that seed is considered as vigoures (ISTA 1999).

Speed of germination ranged from 13.28 to 7.71 with the grand mean value of 11.77. The maximum speed of germination was observed in the genotype GR-15 (13.28) followed by the genotypes GR-5 (12.73) whereas the minimum speed of germination was observed in the genotype GR-1(7.71) followed by GR-12 (9.87), and these results are similarly find out by. Similar results were found in Ambika (2015) [3] in cluster bean, *Amir* (2015) [1] in cluster bean, Tiwari (2014) [26] in pigeonpea, Hamidi (2013) [13] in sunflower. The genotypes with maximum speed of germination exhibited maximum seed vigour.

Root length ranged from 11.83cm to7.68 cm with the grand mean value of 10.94 cm. The maximum root length was observed in the genotypes GR-15 (11.83cm) followed by the genotypes GR-14(11.80cm),whereas the minimum root length was observed in the genotype GR-1(7.68cm), followed by the genotypes GR-13(8.06cm), and these results are similarly find out by Girish, (2011) [10], Satyavathi *et al.*, (2014). Shoot length ranged from 15.4cm to 10.17cm with the grand mean value of 14.12cm. maximum shoot length was observed in the genotype GR-15 (15.4cm), followed by the genotypes GR-6(14.98cm),whereas the minimum shoot length was observed in the genotype GR-1(10.17cm), followed by the genotypes GR-7(13.21cm), and these results are similarly find out by Wood *et al*. (1977), Jayaraj *et al*. (1998). Root length and shoot length increased in the seed weight, this may be due to greater amount of food reserves contained and the greater embryo size. Shoot length is an important parameter to justify the vigorous nature of seed. Seedling length ranged from 26.96cm to 17.91cm with the grand mean value of 24.37cm. the maximum seedling length was observed in the genotypes GR-15 (26.96cm) followed by the genotypes GR-16(26.28cm), whereas the minimum seedling length was observed in the genotype GR-1(17.91cm), followed by the genotypes GR-13(22.06cm), and these results are simillarly find out by Tiwari, A.S., Dabhi, B.M., Chouksey, H. and Singh, A. (2014) [26], Aamir I M (2015) [1].

Seedling fresh weight ranged from 4.1g to 2.65g with the grand mean value of 3.51g. the maximum seedling fresh weight was observed in the genotype GR-15 (4.1g) followed by the genotypes GR-13(3.92g), whereas the minimum seedling fresh weight was observed in the genotype GR-1(2.65g), followed by the genotypes GR-2(3.1g), and these results are simillarly find out by Ansari *et al.*, (2017) [6] Malaghan (2012). Seedling dry weight ranged from 0.48g to 0.20g with the grand mean value of 0.34g. the maximum seedling dry weight was observed in the genotype GR-15 (0.48Gg) followed by the genotypes GR-7(0.46g), whereas the minimum seedling dry weight was observed in the genotype GR-1(0.20g), followed by the genotypes GR-2(0.26g), and these results are simillarly find out by Krishnan *et al*. (1984). The increase in weight may be due to the rapid germination, which cause elongation of roots and resulted in increase in its dry weight.

Seed vigor index ranged from 2401.5 to 803.93 with the grand mean value of 2002.2. The maximum viability was observed in the genotype GR-15(2401.5) followed by the genotypes GR-12(2247.56), whereas the minimum seed vigour index I was observed in the genotype GR-1(803.93), followed by the genotypes GR-13(1749.2). Seed vigor index II ranged from 42.88 to 9.22 with the grand mean value of 28.40. The maximum viability was observed in the genotype GR-15(42.88) followed by the genotype GR-7(37.20) whereas the minimum seed vigor index II was observed in the genotype GR-1(9.22), followed by the genotypes GR-2(21.64). Seed vigor ranged from 83 to 36.75 with the grand mean value of 75.48. the maximum viability was observed in the genotype GR-15(83) followed by the genotype GR-12(82.75), whereas the minimum seed vigor was observed in the genotype GR-1(36.75), followed by the genotypes GR-8(71) and these results are simillarly find out by Khan *et al.* (2003) in Sunflower, Ashish (2010), Ghassemi *et al.* (2008) in Lentil, Muhammad and Nazir (2010) in rice, Yari *et al.* (2010) in wheat, Khatun and Bhuiyan (2011) in chickpea. Seed vigour, a single concept reflecting several characters determines the seed quality and uniform emergence potential of plants in field under variable range of environment. (Finchsavage and bassel 2016.)

The Electrical conductivity of seed leachates ranged from 1.183 to 1.732 dSm^{-1} with grand mean value of 1.318dSm^{-1}. the minimum electrical conductivity of seed leachates was observed in the genotype GR-15 (1.183 dSm^{-1}) followed by the genotype GR-16(1.24dSm^{-1}), whereas the maximum Electrical conductivity was observed in the genotype GR-1(1.73dSm^{-1}), followed by the genotypes GR-2(1.36dSm^{-1}), and these results are simillarly find out by Priestley (1958), found that the electrical conductivity of cotton seed soaking solution was inversely proportional to germination, but until that time there was no mention of this analysis with possible evaluation of seed vigor. The principle of the EC test is that less vigorous or more deteriorated seeds show a lower speed of cell membrane repair during seed water uptake for germination and therefore release greater amounts of solutes to the external environment. Higher seed leachates conductivity could also be an indicator of reduced seed coat membrane integrity. Vashisth and Nagaranjan (2010).

Table 1: Studies on seed quality parameters in cluster bean [*Cymopsis tetragonoloba* (L.) Taub- guar]

Genotype	Germination	Density	TSW	Fresh wt.	Dry wt.	Ec	Root length	Shot lenth	Seedling length	Seed vigour	Vigour index i	Vigour index ii	Speed of germ.
GR1	45	27.2	29	2.65	0.205	1.732	7.68	10.17	17.91	36.75	803.93	9.22	7.717
GR2	81.75	34.5	34.45	3.1	0.265	1.36	8.98	14.21	22.95	72.25	1871.48	21.64	12.32
GR3	87.25	32	30.875	3.525	0.405	1.259	10.91	14.33	25.25	77.5	2197.01	35.40	12.09
GR4	81.5	35.75	32.85	3.8	0.455	1.353	11.62	14.15	25.58	74.5	2086.66	37.07	12.67

GR5	86.25	35.95	35.425	3.25	0.2875	1.301	11.55	14.45	25.98	79.75	2231.03	25.04	12.73
GR6	83.5	34.35	33.6	3.75	0.31	1.289	9.75	14.98	24.71	80.5	2052.05	25.91	12.17
GR7	81.25	30.45	30.325	3.425	0.4575	1.287	9.06	13.21	22.27	77.25	1809.83	37.20	11.94
GR8	80.25	34.05	34.075	3.5	0.44	1.312	9.73	14.12	23.88	71	1919.56	35.25	12.27
GR9	84	33.15	33.375	3.375	0.375	1.279	10.37	14.58	24.92	82	2094.16	31.12	12.54
GR10	82.5	34.2	29.325	3.9	0.3525	1.267	9.26	14.48	23.75	71.75	1961.41	29.10	12.57
GR11	87	35	34.925	3.725	0.2875	1.34	11	14.93	25.91	81.75	2245.8	25.05	11.92
GR12	86.75	32.55	31.725	3.1	0.27	1.321	11.75	14.16	25.96	82.75	2247.56	23.33	9.875
GR13	79.25	34.3	32.575	3.925	0.2975	1.294	8.06	14	22.06	80.25	1749.2	23.57	11.32
GR14	85.25	35.4	33.2	3.575	0.3225	1.262	11.8	13.83	25.51	76.75	2178.6	27.46	11.02
GR15	89	36	36.3	4.1	0.482	1.183	11.83	15.4	26.96	83	2401.5	42.88	13.28
GR16	83	32.35	32.35	3.6	0.3025	1.244	11.31	14.95	26.28	80	2176.78	25.08	11.94
Grand mean	81.468	33.56	32.77	3.51	0.34	1.318	10.94	14.12	24.37	75.48	2002.2	28.40	11.77
SE(d)	2.67	0.82	0.50	0.17	0.25	0.02	1.06	1.18	1.96	6.04	159.77	2.09	0.55
SE(m)	1.89	0.58	0.35	0.12	0.17	0.01	0.75	0.83	1.39	4.27	112.98	1.48	0.39
CD (5%)	5.38	1.64	1.01	0.35	0.05	0.04	2.14	2.38	3.95	12.16	321.25	4.21	1.12
CV	4.65	3.45	2.18	7.16	10.38	2.56	14.65	11.88	11.42	11.33	11.28	10.44	6.69
Range Max	89	36	36.3	4.1	0.482	1.183	11.83	15.4	26.96	83	2401.5	42.88	13.28
Range Min	45	27.2	29	2.65	0.205	1.732	7.68	10.17	17.91	36.75	803.93	9.22	7.717

Conclusion

The evaluation is based on seed quality parameters of different genotype of cluster bean. Genotypes taken from directorate of seed and farms SHUATS, Prayagaraj.

On the basis of results obtained from the present experiment following conclusions are drawn.

The evaluation of seed quality parameters of different genotype of clusterbean, significantly in lab condition. Total 16 genotypes check in this experiment and observe on the basis of mean performance, the genotype GR-15 has been identified as the best genotype for the seed quality parameter *viz*., test weight, germination percentage, density, speed of germination, root length & shoot length, seedling length, fresh weight & dry weight, vigor index I & vigor index II, and electrical conductivity, whereas genotype GR-1 showed lowest for all the characters studied.

These conclusions are based on the results of six months investigation and therefore further investigation is needed to arrive at valid recommendation.

References

1. Aamir IM. Cluster Bean (*Cyamopsis tetragonoloba* L.) Germination and Seedling Growth as Influenced by Seed Invigoration Techniques. American-Eurasian Journal of Agriculture & Environment Science. 2015; 15(2):197-204.
2. Adat SS, Chavan AB, Savvashe AY, Sonavane PN, Chalke PR. Studies on growth parameters of clusterbean (*Cyamopsis Tetragonoloba*) varieties under Marathwada condition. Green Farming. 2011; 2(6):684-685.
3. Ambika S, Balakrishnan K. Enhancing germination and seedling vigour in cluster bean by organic priming. Scientific Research and Essays. 2015; 10(8):298-301.
4. Anonymous. Annual Report, Ministry of Agriculture, Government of India, 2013. http://www.commoditiescontrol.com/eagritrader/staticpages/index.
5. Anonymous. Directorate of Economics and statistics, Department of Agricultural and Cooperation New Delhi. India, Annual progress report, 2012.
6. Ansari ZG, Rao R, Vasht D, Sreelatha P, Aparna K. Evaluation of morpho-physiological traits at various growth stages and its correlation with seed yield in guar gum genotypes. Int. J Chemi. Studies. 2017; 5(6):909-912.
7. AOSA (2003).Rules for testing seed. Association of official seed analysts Las Cruces. NM.
8. Arora D, Dhillon NPS, Sidhu AS. Characterization and evaluation of North Indian cluster bean [*Cyamopsis tetragonoloba* (L.) Taub] germplasm collection. Electronic J Plant Breed. 2011; 2(3):417-421.
9. Futuless K, Bake N, Ibrahim D. Evaluation of yield and yield attributes of some cowpea [*Vignaunguiculata* (L.) walp] varieties in Northern Guinea Savanna. J American Sci. 2010; 6(10):671-674.
10. Girish MH, Gasti VD, Kerutagi MG, Mulge R, Mastiholi AB, Thammaiah N *et al*. Economics of cluster bean production in Ghataprabha Left Bank Command Area. J Asian Hort. 2011; 7(3):142-145.
11. Gresta F, Sortino O, Santonoceto C, Issi L, Formantici C, Galante Y. Effects of Sowing Times on Seed Yield, Protein and Galactomannans Content of Four Varieties of Guar (*Cyamopsis tetragonoloba L.*) in a Mediterranean Environment. Industrial Crops and Products. 2013; 41:46-52.
12. https://doi.org/10.1016/j.indcrop.2012.04.007
13. Hamidi R. Comparison Effect of different Seed priming methods on Sunflower Germination and seedling growth. International Journal of Agronomy and Plant Production. 2013; 4(6):1247-1250
14. ISTA. Rules amendments. Seed Science Technology. 2001; 29(2):132.
15. Karawya MS, Ammar NM, Alokbl SY. Studies on guar as hypoglycemic agent. Egyptian J Food Sci. 1994; 22(1):1-12.
16. Lal S. Grow multipurpose use crop-Guar. *Kheti*. 1985; 38(14):24-27.
17. Lee JT, Connor AS, Haq AU, Bailey CA, Cartwright AL. Quantitative measurement of negligible trypsin inhibitors activity and nutrient analysis of guar mean fraction. J. Agric. Food Chem. 2004; 52(21):6492-6495.
18. Omkarappa T. Germplasm evaluation for genetic variability to yield and yield contributing characters in cow pea [*Vigna unguiculata* (L.)Walp].*M.Sc. (Hort.) Thesis*, Univ. Agric. Sci., Bangalore (India), 1994.
19. Panse VG, Sukhatme PV. *Statistical Methods for Agricultural Workers*. Indian Council of Agricultural Research, New Delhi, 1967, 145.
20. Pathak R, Roy MM. Climatic responses, environmental indices and interrelationships between qualitative and quantitative traits in cluster bean under arid condition.

Proceedings of the National Academy of Sciences, India Section B (Biological Science). 2015; 85(1):147-154.
21. https://doi.org/10.1007/s40011-013-0269-4
22. Rozina G, Sajid A, Hamayoon K, Nazia, Farhan A, Imran A. Variablity among mung bean (*Vigna radiata*) genotypes for yield and yield components grown in Peshawar valley. J Agric. Biol. Sci. 2007; 2(3):6-9.
23. Satyavathi P, Vanaja M, Vagheera P, Vijaykumar G, Sathish P, Ira Khan. Genotypic variability and seasonal impact on biomass and yield performance of cluster bean. International Journal for Current Sciences. 2017; 20(3):E 1-9.
24. Senapati MK, Srinatha A, Pandit JK. *In vitro* release characteristics of matrix tablets: Study of Karya gum and guar gum as release modulators. Indian J Pharmaceutical Sci. 2006; 68(6):824-826.
25. Singh VP, Paroda RS. The winged bean: A Review. Haryana J Hort. Sci. 1983; 12(3-4):200-211.
26. Tiwari AS, Dabhi BM, Chouksey H, Singh A. Effect of fertility and sulphur levels on quality parameter of summer clusterbean (*Cyamopsis tetragonoloba* L.) under south saurastra region. *ISSN: 2319-7706.* 2014; 3:330-334.