*Forage Res.*, **52**(1) : pp. 17-22 (2026) **http://forageresearch.in**

# CORRELATION AND PATH ANALYSIS FOR YIELD CONTRIBUTING TRAITS IN INTRASPECIFIC POPULATION (HG 75 × PNB) OF CLUSTER BEAN

**PRITI, RAM C. YADAV AND NEELAM R. YADAV***

Department of Molecular Biology, Biotechnology and Bioinformatics
CCS Haryana Agricultural University, Hisar-125 004 (Haryana), India
**(e-mail: nryadav58@gmail.com)*

**(Received: 2 June 2026; Accepted: 26 June 2026)**

**SUMMARY**

Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.] is a cash crop as the presence of endospermic galactomannan gum in seeds. Hence yield improvement of this crop has been a prime objective for breeders worldwide. In the present study, correlation and path analysis was carried out to comprehend the true association of yield and yield attributing traits like, plant height, branches per plant, cluster per plant, pods per cluster, pods per plant, pod length, days to 50% flowering, days to maturity, 100 seed weight, seed yield per plant in 68 lines of $F_{4-5}$ intraspecific population (HG75×PNB) of cluster bean. Our study witnessed the maximum direct effect on seed yield per plant by pods per plant (0.612), followed by hundred seed weight (0.336) and clusters per plant (0.178). Thus, number of pods per plant, hundred seed weight and clusters per plant had the true positive association with seed yield per plant under BLB conditions and should be considered as selection criteria while selecting plants with improved yield.

**Key words:** Cluster bean, HG 75, PNB, galactomannan gum, path analysis

Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.] is a self-pollinated crop with chromosome number 2n=2x=14. Cluster bean is an important vegetable belonging to the family *Fabaceae* and popularly known as 'guar'. The young pods are a rich source of protein (3.2 g), carbohydrate (10.8 g), energy (16 kcal), fat (1.4 g), vitamin A (65.3 IU), vitamin C (49 mg), moisture (81%), calcium (57 mg) and iron (4.5 mg) for every 100 g of the edible fresh part harvested for vegetable purpose (Muftuoglu *et al*., 2019). Cluster bean is a drought tolerant crop that grows better in warm climate. Thereby, this crop is very popular in arid and semi-arid regions of tropics where other legumes do not perform well. Besides being a vegetable crop, cluster bean is an important industrial crop grown for its endospermic galactomannan gum. This gum is a galactomannan polysaccharide and has profound applications in oil and gas drilling, textile, pharmaceuticals, paper, water treatment, *etc*. (Coveney *et al*., 2000, Undersander *et al*., 1991). In India, cluster bean is mainly grown in Rajasthan, Haryana, Gujarat, Punjab, Uttar Pradesh, Madhya Pradesh, and Tamil Nadu (Pathak *et al*., 2010). Even though it has great potential as an industrial as well as a vegetable crop, it encounters many biotic and abiotic factors limiting the yield potential of the crop. Bacterial leaf blight (BLB) is one of the most devastating diseases of cluster beans caused by *Xanthomonas campestris* pv. *Cyamopsidis* pathogen. In India, 68% yield losses have been reported due to BLB in cluster beans (Gandhi and Chand, 1985).

The objective of most breeding programs mainly revolves around the improvement of crop yield. Yield is a complex character controlled by many genes. The selection of plants purely on the basis of yield alone may be misleading. Hence, crop yield can be improved through knowledge of the interrelationship among yield and yield contributing attributes (Takele *et al*., 2021). Indirect improvement of a desirable trait can be achieved through improving another trait if they are in a positive correlation. Path analysis eventually partitions the correlation of the independent variable into direct and indirect effects exerted on the dependent variable, *i.e*., seed yield per plant in this study. The present study was initiated to study the association between seed yield per plant and attributing traits under natural BLB disease infection in $F_{4-5}$ intraspecific (HG 75 × PNB) population of cluster bean. HG75 is a high-yielding variety and moderately resistant to BLB, whereas *Pusa Nav Bahar* (PNB) is a vegetable type, non-branching and highly sensitive to the disease. Thus, segregating population derived from

the cross has variation among phenotypic characters that will be useful in selecting superior plant type.

## MATERIALS AND METHODS

### Raising of the population

An intraspecific cross was made between HG 75 and the PNB variety of guar, and subsequent generations were grown in the farm area of Forage Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar. The $F_1$ plants obtained from this cross were grown to raise the $F_2$ population. Further, seeds from individual $F_2$ plants were harvested to grow the F2-3 population. Subsequently, the $F_{4-5}$ population was raised during the 2016 growing season and utilized for the present study. A total 68 lines of $F_{4-5}$ segregating population were used for further phenotypic and genotypic analysis.

### Yield attributes

The yield attributes were recorded in parents of the Intraspecific cross (HG 75 and PNB) along with segregating population. Plant height (cm), branches per plant, cluster per plant, pods per cluster, pods per plant, pod length (cm), days to 50% flowering, days to maturity, 100 seed weight (g), seed yield per plant (g) were taken in to account for analysis.

### Disease Scoring

Observations for disease intensity of bacterial leaf blight were recorded in natural conditions using 0-5 disease scale given by Wheeler (1969). The percent disease index was calculated as:

$$\text{Percent Disease Index} = \frac{\text{Sum of all individual rating}}{\text{Total no. of leaves assessed} \times \text{Maximum rating}} \times 100$$

Five plants from each replication selected randomly, were tagged and further assessed for percent disease index calculation (Table 1).

### Statistical analysis

Descriptive statistical analysis of the data such as mean, range, standard deviation, standard error, and coefficient of variation, correlation coefficient, and path coefficient analysis were performed using OPSTAT software (Sheoran *et al*., 1998).

TABLE 1
Disease reaction categorization (percent disease index) calculated from BLB infected leaf (Highly resistant: HR, Resistant: R, Moderately resistant: MR, Moderately susceptible: MS, Susceptible: S and highly susceptible: HS)

| Grade | Disease Reaction | Percent Disease Index/Percent leaf area infected |
|---|---|---|
| 0 | HR | 0 |
| 1 | R | 1-10 |
| 2 | MR | 11-20 |
| 3 | MS | 21-40 |
| 4 | S | 41-60 |
| 5 | HS | >60 |

## RESULTS AND DISCUSSION

Cluster bean breeders are interested in developing high yielding varieties for diverse geographical locations that can encompass yield constraint like BLB. Yield in turn depends on various other components which directly or indirectly affect the yield of the crop. Hence, correlation studies and path analysis studies are important to understand the interaction between yield components to further enhance the yield of the crop. To achieve this goal, basic requirements are to have knowledge on extent of variability and degree of association between yield and yield contributing characters. Statistical analysis showed that yield parameters showed a significant amount of variability in the population.

Intraspecific segregating population $F_{4-5}$ comprising 68 lines along with parents was grown under natural bacterial leaf blight conditions and percent disease index was calculated to screen the level of BLB resistance in population. HG75 showed a moderate resistance to the reaction with PDI value 14.42 while PNB found to be highly susceptible towards BLB with PDI value (86.60). While, rest of the line were characterized under sensitive and highly sensitive as depicted in Table 2.

A considerable variation was observed for different yield attributes among intraspecific population of cluster bean (Table 3). Plant height ranged from 70.00 to 158.80cm with a mean value of 118.74cm, similarly, the number of branches per plant varied from 2.00-14.00 with a mean value of 10.23, number of clusters per plant varied from 7.00-55.00 with the

mean value of 37.11, seed yield per plant ranged from 13.00-43.64 g with the mean value of 23.63 g as depicted in Table 1. Largest coefficient of variation was observed for seed yield per plant (30.07%), followed by pods per plant (26.35%), number of branches per plant (25.81%). Lowest percent of coefficient of variation was observed for day to maturity (2.50%), days to 50% flowering (5.28), pod length (5.61%), hundred seed weight (22.66%). Greater extent of variation was observed in traits like seed yield per plant, pods per plant, clusters per plant, number of branches per plant, plant height, percent disease index. This high coefûcient of variation and range indicates that phenotypic selection is adequate to bring desirable improvement of these characters.

Similarly, Khalid *et al.*, (2017) during his study of morphological analysis of cluster bean genotypes found larger variation in traits like plant height, number of branches per plant, seed yield per plant. Study by Reddy *et al.*, (2018) also found the larger variation in cluster per plant, pods per plant and plant height while evaluating 51 genotypes of cluster bean. Other traits like pod length, days to 50% flowering, and days to maturity, and hundred seed weight were having lower range of variation. These results are further supported by previously reported studies (Kumar and Ram, 2015; Boghara *et al.*, 2016) while studying cluster bean genotypes.

TABLE 3

Basic statistical analysis of observed variables among of $F_{4-5}$ intraspecific population (HG 75 × PNB) of cluster bean

| Character | Mean | Range | SD | SE | CV (%) |
|---|---|---|---|---|---|
| PH (cm) | 118.74 | 70.00-158.8 | 18.42 | 1.69 | 15.51 |
| BCH | 10.23 | 2.00-14.00 | 2.64 | 0.83 | 25.81 |
| ClP | 37.11 | 7.00-55.00 | 8.42 | 1.38 | 22.69 |
| PdCl | 5.72 | 3.80-8.04 | 0.75 | 0.31 | 13.03 |
| PdP | 135.69 | 18.00-219.40 | 35.76 | 3.10 | 26.35 |
| PL (cm) | 5.54 | 3.90-5.98 | 0.31 | 0.13 | 5.61 |
| FW | 48.43 | 44.00-54.00 | 2.56 | 0.37 | 5.28 |
| DM | 100.77 | 95.00-106.20 | 2.52 | 0.25 | 2.50 |
| HSW | 2.17 | 1.53-2.65 | 0.21 | 0.14 | 9.42 |
| PDI (%) | 66.17 | 19.12-90.60 | 14.99 | 1.84 | 22.66 |
| SY(g) | 23.63 | 13.00-43.64 | 7.11 | 1.46 | 30.07 |

PH- Plant height, BCH- Branches per plant, ClP- Clusters per plant, PdCl- Pods per cluster, PdP- Pods per plant, PL- Pods length, FW- Days to 50% flowering, DM- Days to maturity, HSW- Hundred seed weight (g), SY- Seed yield per plant, PDI- Percent Disease Index.

## Correlation analysis

Pearson correlation matrix was drawn from the observed traits of the intraspecific population of cluster bean as represented in Table 4. Seed yield per plant was highly and significantly correlated in positive direction with the number of branches per plant (r=0.458), clusters per plant (r=0.667), pods per plant (r=0.805), and hundred seed weight (r=0.656) at $p<0.01$ while seed yield per plant is in negative correlation with PDI (-0.363) at $p<0.01$ and days to 50% flowering (-0.262) at $p<0.05$.

Likewise, Vir and Singh, (2015) while studying cluster bean germplasm over two seasons found that number of pods per plant, number of clusters per plant had significant correlation with seed yield per plant in positive direction. Similar pattern of correlation of yield with other traits have been reported in cluster bean. For instance, a study by Khalid *et al.*, (2017) while screening 100 genotypes of cluster bean, found positive significant correlation of yield with clusters per plant and pods per plant and negative correlation with days to 50% flowering.

TABLE 2

Disease severity for bacterial leaf blight recorded at research area of Forage Section, Department of G&PB, CCS Haryana Agricultural University, Hisar in $F_{4-5}$ population of HG 75 ×PNB

| Percent Disease Index (%) | Disease reaction | Line No. |
|---|---|---|
| 0 | HR | Nil |
| 1-10 | R | Nil |
| 11-20 | MR | 8, 16, 27 |
| 21-40 | MS | 3, 28,36 |
| 41-60 | S | 9,10, 14, 20, 23, 38, 48, 49, 50, 51, 52, 75 |
| >60 | HS | 2, 5, 7, 11, 12, 13, 15, 17, 18, 19, 21, 22, 24, 26, 29, 30, 31, 32, 33, 34, 35, 37, 39, 41, 42, 43, 44, 45, 46, 47, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 73 |
| 14.42 | MR | HG75 |
| 86.60 | HS | PNB |

**Path correlation analysis**

Correlation studies become more meaningful when correlation coefficient can be partitioned in to direct and indirect effects by path analysis studies. Maximum direct effect was observed on seed yield per plant *via* pods per plant *i.e*. 0.612 which is 76.02% of total effect (0.805) as shown in Table 5. The remaining 21.86% positive indirect effect of pods per plant on seed yield per plant is due to hundred seed weight. Despite of exerting negative indirect effects *via* plant height (-.008), number of branches per plant (-0.014), pods per cluster (-0.062), pod length (-0.058), days to 50% flowering (-.017), pods per plant had positive significant association with seed yield per plant, which indicated that pods per plant is very important character for enhancing yield in cluster bean. Remzeena and Aneetha, (2021) also recorded the highest direct effect on seed yield per plant by pods per plant during their study on different accessions of cluster bean.

Second maximum direct effect on seed yield per plant was observed by hundred seed weight (0.336) 51.21% of total effect (0.656). In another study, Kumar *et al.* (2019) reported significant positive direct effect by hundred seed weight on seed yield per plant while evaluating the morphological characters of 50 accessions of cluster bean. Other than pods per plant and hundred seed weight, characters like clusters per plant (0.178), days to 50% flowering (0.104) also had direct positive effect on seed yield per plant. Clusters per plant showed a highly significant positive association (0.667) with seed yield per plant suggesting it as an important character in improving yield in cluster bean. While, days to 50% flowering had the significant negative association with seed yield per plant according to correlation studies. This negative association may be due to that fact that days to 50% flowering exerting overall indirect negative effect on seed yield per plant *via* almost every character except pod length. Ahmad *et al.* (2020) also found in their study that the days to 50% flowering had the overall negative association with seed yield per plant and had negative indirect effect on seed yield per plant *via* most of the characters. Thus, days to 50% flowering should not be considered while selecting superior plant type in cluster bean.

Plant height showed the negative direct effect (-0.039) on seed yield per plant while, correlation studies depicted a non-significant association of plant height with seed yield per plant. As plant height also exerting positive indirect effect *via* clusters per plant (0.036), pods per plant (0.131), days to 50% flowering (0.056) and negligibly by pods per cluster (0.002), this may be the reason of non-significant association with seed yield per plant. So, this trait cannot be considered while selecting the plants for higher yield. Similarly, branches per plant, pods per cluster, pod length, days to maturity and percent disease index exerted negative direct effect on seed yield per plant *i.e*. -0.026, -0.081, -0.340, -0.132 and -0.074, respectively.

A study by Lekshmanan and Vahab, (2016) also reported the negative direct effect of number of

TABLE 4

Pearson correlation coefficient analysis of agronomic data collected for 68 lines of $F_{4-5}$ intraspecific population (HG 75 × PNB)

| Traits | PH | BCH | ClP | PdCl | PdP | PL | FW | DM | HSW | PDI | SY |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PH | 1 | 0.087 | 0.203 | -0.012 | 0.214 | 0.006 | 0.537** | 0.501** | -0.062 | 0.248* | 0.077 |
| BCH | | 1 | 0.702** | 0.203 | 0.542** | 0.242 | 0.021 | 0.002 | 0.399** | -0.184 | 0.458** |
| ClP | | | 1 | 0.119 | 0.784** | 0.356** | -0.095 | -0.031 | 0.502** | -0.189 | 0.667** |
| PdCl | | | | 1 | 0.340** | -0.142 | -0.069 | -0.132 | 0.141 | -0.011 | 0.150 |
| PdP | | | | | 1 | 0.171 | -0.160 | -0.119 | 0.524** | -0.262* | 0.805** |
| PL | | | | | | 1 | -0.023 | -0.052 | 0.272* | -0.083 | -0.051 |
| FW | | | | | | | 1 | 0.878** | -0.349** | 0.231 | -0.262* |
| DM | | | | | | | | 1 | -0.339** | 0.195 | -0.225 |
| HSW | | | | | | | | | 1 | -0.354** | 0.656** |
| PDI | | | | | | | | | | 1 | -0.363** |
| Yl | | | | | | | | | | | 1 |

PH- Plant height, BCH- Branches per plant, ClP- Clusters per plant, PdCl- Pods per cluster, PdP- Pods per plant, PL- Pods length, FW- Days to 50% flowering, DM- Days to maturity, HSW- Hundred seed weight (g), SY- Seed yield per plant, PDI- Percent Disease Index.

TABLE 5
Direct (bold in diagonal) and indirect effects (off-diagonal) of agronomic traits and bacterial blight disease index on seed yield in $F_{4-5}$ intraspecific cluster bean population

| Traits | PH | BCH | ClP | PdCl | PdP | PL | FW | DM | HSW | PDI | Genotypic Correlation for SY |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PH | **-0.039** | -0.002 | 0.036 | 0.002 | 0.131 | -0.002 | 0.056 | -0.066 | -0.021 | -0.018 | .077 |
| BCH | -0.003 | **-0.026** | 0.125 | -0.037 | 0.332 | -0.082 | 0.002 | 0.000 | 0.134 | 0.014 | 0.458** |
| ClP | -0.008 | -0.018 | **0.178** | -0.022 | 0.480 | -0.121 | -0.010 | 0.004 | 0.169 | 0.014 | 0.667** |
| PdCl | 0.000 | -0.005 | 0.021 | **-0.181** | 0.208 | 0.048 | -0.007 | 0.017 | 0.047 | 0.001 | 0.150 |
| PdP | -0.008 | -0.014 | 0.140 | -0.062 | **0.612** | -0.058 | -0.017 | 0.016 | 0.176 | 0.019 | 0.805** |
| PL | 0.000 | -0.006 | 0.063 | 0.026 | 0.104 | **-0.340** | -0.002 | 0.007 | 0.091 | 0.006 | -0.051 |
| FW | -0.021 | -0.001 | -0.017 | 0.013 | -0.098 | 0.008 | **0.104** | -0.116 | -0.117 | -0.017 | -0.262* |
| DM | -0.019 | 0.000 | -0.006 | 0.024 | -0.073 | 0.018 | 0.092 | **-0.132** | -0.114 | -0.014 | -0.225 |
| HSW | 0.002 | -0.010 | 0.090 | -0.026 | 0.321 | -0.092 | -0.036 | 0.045 | **0.336** | 0.026 | 0.656** |
| PDI | -0.010 | 0.005 | -0.034 | 0.002 | -0.160 | 0.028 | 0.024 | -0.026 | -0.119 | **-0.074** | -0.363** |

PH- Plant height, BCH- Branches per plant, ClP- Clusters per plant, PdCl- Pods per cluster, PdP- Pods per plant, PL- Pods length, FW- Days to 50% flowering, DM- Days to maturity, HSW- Hundred seed weight (g), SY- Seed yield per plant, PDI- Percent Disease Index.

branches on pod yield per plant while studying 100 accessions of cluster bean. In other legumes like chickpea also, this type of negative direct effect of branches per plant yield per plant was also observed by Bhanu *et al.* (2017), suggesting that selection of non-branching types would result in better seed yield per plant. Similarly, Jayaparda *et al.* (2019) noticed that plant height, no of branches, and days to maturity had a negative direct effect on seed yield per plant while studying the 20 genotypes of green gram.

Thus, characters studied from correlation and path analysis, number of pods per plant, hundred seed weight and clusters per plant had the true positive association with seed yield per plant and should be considered as selection criteria and would be rewarding in the yield improvement of the cluster.

## ACKNOWLEDGEMENT

We sincerely acknowledge Dr. Surender Kumar Pahuja from the Forage Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar, for providing the research facilities, field resources, and technical support required for conducting this study.

## FUNDING

This work was supported by a grant from the Director of Research, CCS Haryana Agricultural University, Hisar, India [C(a) BMB-6-Plan (Agri.)].

## REFERENCES

Ahmad, S., and V. Belwal, 2020 : Study of correlation and path analysis for yield and yield attributing traits in mungbean [*Vigna radiata* (L.) *Wilczek]. Int. J. Chem. Stud.*, **8**(1): 2140-2143.

Bhanu, A. N., M. N Singh., R. Tharu and S. K. Saroj, 2017 : Genetic variability, correlation and path coefficient analysis for quantitative traits in chickpea genotypes. *Indian J. Agric. Res.*, **51**(5): 425-430.

Boghara, M. C., H. L. Dhaduk, S. Kumar and M. J. Parekh, 2016 : Genetic divergence, path analysis and molecular diversity analysis in cluster bean (*Cyamopsis tetragonoloba* L. Taub.). *Ind. crops prod*, **89**: 468-477.

Coveney, P. V., H. D. Silva, A. Gomtsyan, A. Whiting and E. S. Boek, 2000 : Novel approaches to cross-linking high molecular weight polysaccharides: application to guar-based hydraulic fracturing fluids. *MolSimul*, **25:** 265–299. https://doi.org/10.1080/08927020008024503.

Gandhi, S. K., and J. N. Chand, 1985 : Yield losses in cluster bean due to bacterial blight caused by *Xanthomonas campestris* pv. *cyamopsidis*. *Indian Phytopathol.*, **38:** 516–519.

Jayaprada, T. A., G. R. Lavanya, V. R. Babu, N. S. Krishna and T. S. Reddy, 2019 : Correlation and Path Analysis of Yield Contributing Traits and Seed Yield in Green gram [*Vigna Radiata* (L.) Wilczek]. *Indian J. Agric. Res.*, **53**(6): 753-755.

Khalid, M. A. R., L. H. Akhtar, R. Minhas, S. J. Bukhari, M. Zubair and M. A. Iqbal, 2017 : Screening of guar accessions [*Cyamopsis tetragonoloba* (L.)

Taub.] for higher yield potential under irrigated conditions. *Afr. J. Agric. Res.*, **12**(37): 2788-2794.

Kumar, N., R. S. Khatri, S. Arya, R. Panchta and Satpal, 2019 : Correlation and Path analysis in cluster bean [*Cyamopsis tetragonoloba* (L) Taub]. *Forage Res*., **45**(1): 76-78.

Kumar, V. and R. B. Ram, 2015 : Genetic variability, correlation and path analysis for yield and yield attributing traits in cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.] genotypes. *Int. J. Pure Appl. Biosci.*, **3**(1):143-149.

Lekshmanan, D. K., and M. A. Vahab, 2018 : Correlation and path coefficient analysis of yield and its components characters among different accessions of cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.]. *Legum. Res.*, **41**(1): 53-56.

Müftüoðlu, N.M., C. Türkmen, M. Akçura, and M. Kaplan, 2019: Yield and nutritional characteristics of edible cluster bean genotypes. *Turk. J. Field Crops*, **24**: 91-97.

Pathak, R., S. K. Singh, M. Singh, and A. Henry, 2010 : Molecular assessment of genetic diversity in cluster bean (*Cyamopsis tetragonoloba*) genotypes. *J. Genet.*, **89**: 243-246.

Reddy, D. R., P. Saidaiah, K. R. Reddy, S. R. Pandravada and A. Geetha, 2018 : Genetic variability for growth, pod and quality attributes in germplasm of cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.]. *Legum Res.*, **3917:** 1-5. DOI:10.18805/LR-3917

Remzeena, A., and P. Anitha, 2021 : Correlation and Path Coefficient Analysis in Cluster Bean [*Cyamopsis tetragonoloba* (L.) Taub.] Genotypes. *Agric. Sci. Digest.,* DOI: 10.18805/ag.D-5385.

Sheoran, O. P., D. S. Tonk, L. S. Kaushik, R. C. Hasija and R. S. Pannu, 1998 : Statistical Software Package for Agricultural Research Workers. Recent Advances in information theory, Statistics and computer applications by D S Hooda and R C Hasija Department of Mathematics Statistics, CCS Haryana Agricultural University, Hisar. Pp. 139-143.

Takele, F., D. Lule and S. Alemerew, 2021 : Correlation and path coefficient analysis for yield and its related traits in sesame (*Sesamum indicum* L.) genotypes. *Agric. Vet. Sci.,* **9**(1): 52-64.

Undersander, D. J., D. H. Putnam, A. R. Kaminski, K. A. Kelling, J. D. Doll, E. S. Oplinger and J. L. Gunsolus, 1991 : Guar. Alternative Field Crop Manual University of Wisconsin Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant and Animal Products, 1991. https:// hort.purdue.edu/newcrop/afcm/guar.

Wheeler, B. E. J., 1969 : An introduction to plant diseases. John & Wiley and Sons, New York.