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# Genetic diversity, correlation and path coefficient analysis of rajma bean (*Phaseolus vulgaris*) landraces in low altitude of Nagaland

A THIRUGNANAVEL[1], BIDYUT C DEKA[2], RAKESH KUMAR[3], LILY RANGNAMEI[4] and MEGHOKHONO MEYASE[5]

*ICAR RC for NEH Region, Nagaland Centre, Jharnapani, Nagaland 797 106, India*

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ABSTRACT

Thirty two rajma beans (*Phaseolus vulgaris* L.) landraces have been evaluated for 17 traits to study the genetic variability, correlations and direct and indirect effect of characters on yield. Results showed that wide range of variations were observed for all 17 traits among the landraces. Moderate to high level of GCV and PCV and high level of heritability were observed for all the traits. PCV was slightly higher than GCV, but the difference was insignificant. The traits such as plant height, number of seeds/plant, number of pods/plant, test weight and seed yield recorded high level of GCV, PCV and heritability. Correlation results showed that seed yield had positive and high correlation ($p < 0.01$) with umber of seeds per plant, number of pods per plant, test weight and seed weight. It was observed that number of seeds per plant had high positive correlation with number of pods per plant and number of seeds per pod had high positive correlation with locules per pod. The results of path coefficient analysis showed that no. of seeds per plant and seed weight had very high level to high level of positive direct effect on seed yield. Based on findings, no. of seeds per plant, no. of pods per plant, test weight, no. of flowers per inflorescence and plant height are identified as very important traits in selection for improving the rajma bean yield.

**Key words:** GCV, Genetic advance, Heritability, Improvement, PCV, Rajma

Rajma or common bean (*Phaseolus vulgaris* L.), one of the oldest cultivable crops, is an important food legume in the world (Matthew *et al*. 2011). A native of Central and South America, common bean is cultivated widely in temperate and subtropical regions of the world (Zeven *et al*. 1999). Seeds are rich in protein, fibre, and starch and often called as poor man's meat (Beebe *et al.* 2000). The beans are rich in minerals particularly iron, potassium, manganese, magnesium and are widely consumed food legume among the pulses (Broughton *et al.* 2003). Further, it has a high amount of bioactive compounds, viz. phenolic compounds, lectins, phytates, etc. (Kumar *et al*. 2008). Worldwide, this nutrient-rich food legume is consumed as dry seeds, pods, frozen grain or canned grain and highly preferred by consumers and processing industries (Escribano *et al*. 1997).

Northeast India, one of the hot spot in India (Deka *et al.* 2012), is rich in horticultural genetic diversity. Nagaland is considered one of the richest biodiversity pockets for rajma beans. In Nagaland, it is used as one of the important pulse crops and it is widely grown in *jhum* fields as mixed crop along with a paddy and maize or pure crop after maize. It is also cultivated in backyards and kitchen garden. It is called vernacularly as ajoxa, khetsuthi, ajokha, and khollar (Table 1). In higher altitude, it is mainly sown during February – March and harvested during May – July depending on the cultivars. They are also cultivated during offseason at August (sowing) – November-December (harvest). In lower altitude, it is cultivated during September – October (sowing) and December – January (harvesting). Ethnic people mostly use green pods as fresh vegetable and dried bean as pulse. It is consumed as either boiled or fried and served as one of the important protein sources of plant origin. They hang the dried pod over the kitchen for storage of seeds.

There are several landraces of rajma beans grown by farmers, which vary in shape, size, taste, maturity and in nutritive values. The biodiversity in this region is under serious threat of rapid extinction due to urbanization, depleting soil nutrient status, the introduction of high-value vegetable crops, and climate change (Deka *et al*. 2012).

[1]Scientist (Horticulture) (e mail: lotus.thiru@gmail.com), ICAR-Central Citrus Research Institute, Nagpur 440 033, Maharashtra. [2]Director (e mail: bidyutdeka@yahoo.com), Agricultural Technology Application Research Institute, Umiam, Barapani 793 103, Meghalaya. [3]Scientist (Agronomy) (e mail: rakeshbhu08@gmail.com), ICAR Research Complex for Eastern Region, Patna 800 014, Bihar. [4]Subject Matter Specialist (Horticulture) (e mail: lrangnamei@gmail.com), KVK Longleng, ICAR RC for NEH Region, Nagaland Centre Jharnapani 797 106, Nagaland. [5]Subject Matter Specialist (Horticulture) (e mail: mego_meyase@yahoo.com), KVK Wokha, ICAR RC for NEH Region, Nagaland Centre Jharnapani 797 106, Nagaland

Table 1 Basic details of rajma bean landraces

| District | Local name | Planting time | Harvesting time | Uses |
|---|---|---|---|---|
| Phek | Ajoxa | Feb-March (Main season) | May-June | Vegetable and pulse |
| | | August (Off season) | November | |
| Zunheboto | Khetsuthi, ajokha | Feb-March (Main season) | June – July | It was used as both vegetable and pulse |
| | | August (Off season) | November | |
| Wokha | Khollar | Feb-March | May - July | Vegetable and pulse |
| Tuensang | Khollar | Feb -March (Main season) | May –June | Feb - Vegetable August - Pulse |
| | | August (Off season) | December | |
| Kohima | Khollar | Feb-March | May - July | Vegetable and pulse |

Table 2 List of rajma beans landraces used in this study

| Landrace no | Village | District | Farmers mame | Altitude | Latitude | Longitude |
|---|---|---|---|---|---|---|
| RCN1 | Dzulhami | Phek | Mrs. Yekhwusho | 1814 | 25º49’35” | 94º23’39” |
| RCN2 | Dzulhami | Phek | Mrs. Yekhwusho | 1814 | 25º49’35” | 94º23’39” |
| RCN3 | Dzulhami | Phek | Mrs. Yekhwusho | 1814 | 25º49’35” | 94º23’39” |
| RCN4 | Dzulhami | Phek | Mrs. Yekhwusho | 1814 | 25º49’35” | 94º23’39” |
| RCN5 | Dzulhami | Phek | Mrs. Yekhwusho | 1814 | 25º49’35” | 94º23’39” |
| RCN6 | Aquba | Zunheboto | Mr. Vinito | 1055 | 26º0’37” | 94º34’21” |
| RCN7 | Aquba | Zunheboto | Mr. Vinito | 1055 | 26º0’37” | 94º34’21” |
| RCN8 | Aquba | Zunheboto | Mr. Vinito | 1055 | 26º0’37” | 94º34’21” |
| RCN9 | Sukhalu | Zunheboto | Mr. Zhakhaka | 1835 | 25º58’18” | 94º30’37” |
| RCN10 | Sukhalu | Zunheboto | Mr. Zhakhaka | 1835 | 25º58’18” | 94º30’37” |
| RCN11 | Sataka | Zunheboto | Mr. Kivishe | 1623 | 25º55’12” | 94º27’01” |
| RCN12 | Sataka | Zunheboto | Mr. Kivishe | 1623 | 25º55’12” | 94º27’01” |
| RCN13 | Kilo old | Zunheboto | Mr. Akato Swu | 972 | 25º54’15” | 94º26’2” |
| RCN14 | Kilo old | Zunheboto | Mr. Akato Swu | 972 | 25º54’15” | 94º26’2” |
| RCN15 | Kilo old | Zunheboto | Mr. Akato Swu | 972 | 25º54’15” | 94º26’2” |
| RCN16 | Kilo old | Zunheboto | Mr. Akato Swu | 972 | 25º54’15” | 94º26’2” |
| RCN17 | Lizu Naghuto | Zunheboto | Mrs. Nutoli | 1367 | 26º2’36” | 94º30’37” |
| RCN18 | Lizu Naghuto | Zunheboto | Mrs. Nutoli | 1367 | 26º2’36” | 94º30’37” |
| RCN19 | Lizu Naghuto | Zunheboto | Mrs. Nutoli | 1367 | 26º2’36” | 94º30’37” |
| RCN20 | Lizu Naghuto | Zunheboto | Mrs. Nutoli | 1367 | 26º2’36” | 94º30’37” |
| RCN21 | Kejok | Tuensang | Mr. Kumkia | 1018 | 26º16’24” | 94º50’11” |
| RCN22 | Kejok | Tuensang | Mr. Kumkia | 1018 | 26º16’24” | 94º50’11” |
| RCN23 | Chidema | Kohima | Mr. Vidinil | 1398 | 23º39’54” | 94º6’51” |
| RCN24 | Chidema | Kohima | Mr. Vidinil | 1398 | 23º39’54” | 94º6’51” |
| RCN25 | Wokha | Wokha | Mrs.Yanasali | 1123 | 26º5’51” | 94º13’39” |
| RCN26 | Wokha | Wokha | Mrs.Yanasali | 1123 | 26º5’51” | 94º13’39” |
| RCN27 | Wokha | Wokha | Mrs.Yanasali | 1123 | 26º5’51” | 94º13’39” |
| RCN28 | Wokha | Wokha | Mrs.Yanasali | 1123 | 26º5’51” | 94º13’39” |
| RCN29 | Wokha | Wokha | Mrs.Yanasali | 1123 | 26º5’51” | 94º13’39” |
| RCN30 | Wokha | Wokha | Mrs.Yanasali | 1123 | 26º5’51” | 94º13’39” |
| RCN31 | Longsachung | Wokha | Mr. Ranbemo | 1612 | 26º3’14” | 94º15’41” |
| RCN32 | Longsachung | Wokha | Mr. Ranbemo | 1612 | 26º3’14” | 94º15’41” |

Conservation and utilization of this rich genetic wealth of rajma bean is a major challenge. High yield, resistant to pests and diseases, wider adaptability and short duration are the major criteria for genetic improvement. To improve the existing germplasm for different traits, the knowledge on genetic variability, the characters associated with yield and its heritability is necessary (Saifullah and Rabbani 2009). Till date, the knowledge on genetic diversity of landraces of rajma bean in Nagaland is lacking. Therefore, the present investigation has aimed to assess the genetic diversity of rajma landraces of Nagaland so that the variation in different traits could be utilized in the future breeding programme for its improvement.

## MATERIALS AND METHODS

Thirty two genetically distinct landraces collected from various rajma growing districts of Nagaland were used in this study after ensuring the genetic purity and integrity by selfing each genotype (Table 2). The present experiment was conducted at Horticulture block of an experimental farm, ICAR Research Complex for NEH Region, Nagaland Centre, Jharnapani, Nagaland during October-January in 2013-14 and 2014-15 and executed in the randomized complete block design with three replications. The experimental field is situated at 25°45’24” N longitude and 93°50’26” E latitude with an altitude of 281m msl. Each genotype in each replication was planted at 60 × 60 cm and uniform cultural practices were followed.

Seventeen quantitative traits, viz. plant height (PH, cm), inflorescence length (IL, cm), no. of flowers per inflorescence (NFI), no. of pods per inflorescence (NPI), pod length (PL, cm), pod width (PW, cm), pedicel length (PdL, cm), pod beak length (PBL, cm), seed length (SL, cm), seed width (SW, cm), test weight (TW, g), locules/pod (LP), no. of seeds/pod (NSP), seed weight (SWt, g), no. of pods/plant (NPP), no. of seeds/plant (NSPl), and seed yield/plant (YL, g) were recorded. The data were collected from ten plants in each landrace in each replication.

The genetic variability parameters like genotypic variance (GV), phenotypic variance (PV), phenotypic coefficient of variation (PCV), the genotypic coefficient of variation (GCV), heritability ($h^2$) and genetic advance as percent of mean (GAM) were calculated. The GCV and PCV were categorized as low (<10%), moderate (10-20%) and high (>20%) according to Sivasubramanian and Madhavamenon (1973) and heritability was categorized as low (<30%), medium (31-60%) and high (>60%) according to Robinson *et al.* (1949). The genetic advance as per cent of mean was categorized as low (<10%), moderate (10-20%) and high (>20%) based on Johnson *et al*. (1955). The correlation between yield and its associated characters and among themselves (Johnson *et al*. 1955) and path coefficient analysis (Dewey and Lu 1959) were worked out using the TNAUSTAT statistical package (Manivannan 2014). The direct and indirect effects of path coefficient analysis was categorized as very high (>1.0), high (0.30-0.99), moderate (0.20-0.29), low (0.10-0.19) and negligible (<0.10) according to Lenga and Misra (1973).

Table 3 Estimation of genetic variance for morphological, yield attributing and yield characters

| Traits | Mean | Range | GV | PV | GCV (%) | PCV (%) | h2 (%) | GA (% of mean) |
|---|---|---|---|---|---|---|---|---|
| PH | 109.62 | 239.77 - 27.27 | 2671.74 | 2694.99 | 47.15 | 47.36 | 99.14 | 96.71 |
| IL | 6.22 | 7.83 - 4.07 | 0.88 | 0.89 | 15.07 | 15.16 | 98.80 | 30.86 |
| NFI | 3.89 | 4.77 - 2.97 | 0.22 | 0.23 | 12.05 | 12.36 | 95.09 | 24.21 |
| NPI | 2.31 | 3.6 -1.03 | 0.27 | 0.28 | 22.31 | 22.98 | 94.27 | 44.63 |
| PL | 12.38 | 17.07 - 7.13 | 4.87 | 4.90 | 17.82 | 17.87 | 99.36 | 36.58 |
| PW | 1.20 | 1.53 - 0.87 | 0.03 | 0.04 | 14.36 | 15.68 | 83.89 | 27.10 |
| PdL | 0.80 | 1.07 - 0.43 | 0.03 | 0.03 | 21.25 | 22.57 | 88.60 | 41.20 |
| PBL | 1.02 | 1.87 - 0.43 | 0.11 | 0.11 | 31.90 | 32.41 | 96.90 | 64.70 |
| SL | 1.34 | 2.03 - 0.87 | 0.07 | 0.08 | 19.90 | 20.97 | 90.13 | 38.93 |
| SW | 0.82 | 1.2 - 0.57 | 0.02 | 0.03 | 17.13 | 19.85 | 74.43 | 30.44 |
| TW | 39.11 | 61.73 -18.9 | 112.42 | 122.95 | 27.11 | 28.35 | 91.44 | 53.41 |
| LP | 6.32 | 7.8 - 4.53 | 0.77 | 0.79 | 13.84 | 14.01 | 97.59 | 28.17 |
| NSP | 5.66 | 7.07 - 3.93 | 0.69 | 0.69 | 14.63 | 14.68 | 99.25 | 30.02 |
| Swt | 0.39 | 0.62 - 0.19 | 0.01 | 0.01 | 26.97 | 27.37 | 97.10 | 54.76 |
| NPP | 17.54 | 40.87 - 8.77 | 76.90 | 8.91 | 50.00 | 50.65 | 97.46 | 101.69 |
| NSPl | 98.92 | 250.6 - 36.73 | 2639.97 | 2700.79 | 51.94 | 52.54 | 97.75 | 105.79 |
| SYP | 39.07 | 143.03 - 16.7 | 671.14 | 684.16 | 66.30 | 66.94 | 98.10 | 135.28 |

(PH-Plant height, IL-Inflorescence length, NFI-No of flowers per inflorescence, NPI-No of pods per inflorescence, PL-Pod length, PW-Pod width, PdL-Pedicel length, PBL-Pod beak length, SL-Seed length, SW-Seed width, TW-Test weight, LP-Locules per pod, NSP-No of seeds per pod, Swt-Seed weight, NPP-No of pods per plant, NSPl-No of seeds per plant, SYP-Seed yield per plant)

## RESULTS AND DISCUSSION

The genotypic and phenotypic variations, genotypic and phenotypic coefficient of variations, heritability (broad sense), and genetic advance as percent of mean was worked out and presented in the Table 3. The results revealed that significantly wide range of variations was observed for the 17 quantitative traits studied among the 32 rajma landraces. Among the 17 traits studied, high level of variations were observed for plant height (27.27-239.77 cm), pod length (7.13-17.07), test weight (18.9-61.73), no. of pods/plant (8.77-40.87), no. of seeds/plant (36.73-250.6) and seed yield (16.7-143.03 g). The genetic analysis of quantitative traits is a basic requirement in any plant breeding programme for selection of appropriate breeding strategies. The data on genetic analysis showed that moderate to high level of PCV and GCV were observed for all the traits and the PV and PCV were slightly higher than GV and GCV for all the 17 traits, but the differences between two values were not significant. The higher PCV than GCV indicated the traits are slightly influenced by environment. The highest values of PCV and GCV were recorded in plant height (47.36 and 47.15), no. of pods/plant (50.65 and 50.0), no. of seeds/plant (52.54 and 51.94), and seed yield (66.94 and 66.30) which indicated that these traits have huge impact in improvement of rajma beans. Results of the present study was in accordance with Kamaludin (2011) and Jyothi Devi *et al*. (2015) who reported high level of PCV and GCV for pods/plant and yield/plant in French bean. Allard (1960) suggested that selection of traits in improvement programmes should be based on GCV because it represents the heritable part of total variability. But, GCV alone will not be useful in selection and it could be better to select the traits based on GCV together with heritability (Burton 1952).

Heritability plays a vital role in determining the phenotypic changes observed for different traits are due to genotype or environmental factors. Since the variability controlled by genetic factors only transmitted into offspring, the study on heritability is crucial. In the present study, high level of heritability (>60 %) was found in all the traits and it ranged from 66.67-96.68%. The highest heritability was observed in seed yield/plant (96.88 %), no. of pods/ plant (96.23 %), no. of locules/pod (96.25 %), no. of seeds/plant (95.97 %) and plant height (95.59 %). High heritability in these traits indicated that these characters are controlled genetically and not much influenced by environment. High level of genetic advance as percent of mean was found in all the traits. and it varied from 24.21-135.28 and the maximum GA as percent of mean was observed for the traits, viz. seed yield/plant (135.28), no. of seeds/plant (105.79), no. of pods/plant (101.69), and plant height (96.71). High heritability coupled with high genetic advance will help in selecting the best individual. Based on heritability and genetic advance, the traits, viz. seed yield/plant, no. of pods/ plant, no. of seeds/plant and plant height should be selected in rajma breeding. The results obtained in this study was confirmed by Singh *et al*. (1994), Junaif *et al*. (2010), Rai *et al*. (2010), Sofi *et al.* (2011), Verma *et al*. (2014), and Jyothi Devi *et al.* (2015) who also reported high level of heritability and genetic advance for pods/plant, and yield/ plant in a common bean.

Understanding of correlation between yield and yield components are basic and foremost effort to find out strategies for plant selection. The present study revealed that there was both positive and negative correlation between the yield and the yield components (Table 4). Result showed that number of seeds/plant (0.844), no. of pods/plant (0.839), test weight (0.532) and seed weight (0.532) significantly and positively correlated with grain yield at 0.01 levels of probability while plant height (0.227) and locules/pod (0.238) were significantly but negatively correlated with seed weight at 0.05 probability levels. The negative but significant correlated traits such as plant height showed that shorter parental lines tend to produce more seed weight and vice-versa. The negative correlation between locules/pod and seed weight indicated that simultaneously improving both the traits is difficult and is based on the strength of linkage between the two traits. Further seed yield showed the positive significant correlation between no. of flowers/inflorescence and no. of seed/plant was positively correlated with no. of pods/plant (0.946) and no. of seeds/pod had the positive correlation with locules/pod (0.942). Seed length (0.453) and seed width (0.397) were further positively correlated with test weight. Thus, the seed yield/plant was highly influenced by seed length, seed width, test weight, and no. of seeds/plant. Similar results have been recorded by Rai *et al.* (2010), Kamaludin (2011), Makhdoomi and Dar (2011), and Singh *et al.* (2011) and they reported that seed yield was highly positively correlated with no. of pods/plant, no. of seeds/plant and seed weight. Association of these yield and yield components thus assumes a unique prominence as the basis for selecting desirable rajma genotypes with high yield potential.

Separation of total correlation into direct and indirect effects by path analysis aids in the selection of genotypes more effective (Hasan *et al*. 2013). When correlation study includes many variables, path analysis becomes necessary to explain the true direct and indirect association among the traits (Mohammadi *et al.* 2003). Path coefficient analysis, visualizing direct and indirect effects of yield and yield components are presented in Table 5. The very high positive direct effect of no. of seeds/plant (1.597) and seed weight (0.314) was indicative of their important role in influencing the yield of the rajma bean. Positive indirect effects were found between the number of flowers/inflorescence on seed weight (0.121) and no. of seeds/pod (0.563), locules/ pod (0.375) on no. of seeds/plant respectively. These findings are in accordance with Rai *et al*. (2006), Rai et *al*. (2010), Salehi *et al.* (2010), Kamaludin (2011), Praveen *et al*. (2011) and Jyothi Devi *et al*. (2015) who reported high direct effect on yield by pods/plant, pod width, seed length, seeds/plant and 100 seed weight in common bean. In contradictory to these authours, no. of pods/plant has a high level of negative direct effect on yield in the present study. Although the direct effect of no. of pods per plant

Table 4 Simple correlation among 17 quantitative traits of rajma beans

| | PH | IL | NFI | NPI | PL | PW | PdL | PBL | SL | SW | TW | LP | NSP | SWt | NPP | NSPl | SYP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PH | 1 | 0.179 | 0.201 | -0.254* | -0.069 | -0.051 | -0.07 | -0.216 | -0.192 | -0.070 | -0.235* | -0.177 | -0.162 | -0.227* | -0.019 | -0.016 | -0.163 |
| IL | | 1 | 0.527** | -0.105 | -0.043 | 0.485** | 0.172 | 0.380** | -0.052 | 0.046 | 0.265* | -0.195 | -0.156 | 0.257* | 0.098 | 0.099 | 0.164 |
| NFI | | | 1 | 0.026 | 0.051 | 0.297** | -0.153 | 0.109 | -0.026 | 0.073 | 0.384** | -0.025 | 0.075 | 0.384** | 0.332** | 0.353 | 0.474** |
| NPI | | | | 1 | 0.158 | 0.437** | 0.22 | 0.245* | 0.253* | 0.254* | 0.333** | -0.367** | -0.352** | 0.336** | 0.227* | 0.086 | 0.267* |
| PL | | | | | 1 | 0.105 | -0.066 | 0.025 | 0.309** | 0.184 | 0.046 | 0.373** | 0.223* | 0.057 | -0.028 | -0.049 | 0.071 |
| PW | | | | | | 1 | 0.297** | 0.535** | 0.335** | 0.215 | 0.469** | -0.469** | -0.411** | 0.512** | 0.059 | -0.053 | 0.162 |
| PdL | | | | | | | 1 | 0.472** | 0.160 | 0.184 | 0.213 | -0.411** | -0.567** | 0.211 | -0.055 | -0.218 | 0.012 |
| PBL | | | | | | | | 1 | 0.204 | 0.093 | 0.595** | -0.261* | -0.236* | 0.587** | 0.058 | 0.013 | 0.322** |
| SL | | | | | | | | | 1 | 0.61 | 0.453** | -0.024 | -0.119 | 0.506** | -0.062 | -0.119 | 0.167 |
| SW | | | | | | | | | | 1 | 0.397** | -0.082 | -0.200 | 0.373** | 0.156 | 0.087 | 0.214 |
| TW | | | | | | | | | | | 1 | -0.216 | -0.168 | 0.101 | 0.134 | 0.073 | 0.535** |
| LP | | | | | | | | | | | | 1 | 0.942** | -0.238* | -0.017 | 0.235* | 0.111 |
| NSP | | | | | | | | | | | | | 1 | -0.193 | -0.046 | 0.240* | 0.108 |
| SWt | | | | | | | | | | | | | | 1 | 0.140 | 0.067 | 0.532** |
| NPP | | | | | | | | | | | | | | | 1 | 0.946** | 0.839** |
| NSPl | | | | | | | | | | | | | | | | 1 | 0.844** |
| SYP | | | | | | | | | | | | | | | | | 1 |

*Significance at 5 %: ** Significance at 1%. (PH-Plant height, IL-Inflorescence length, NFI-No of flowers per inflorescence, NPI-No of pods per inflorescence, PL-Pod length, PW-Pod width, PdL-Pedicel length, PBL-Pod beak length, SL-Seed length, SW-Seed width, TW-Test weight, LP-Locules per pod, NSP-No of seeds per pod, Swt-Seed weight, NPP-No of pods per plant, NSPl-No of seeds per plant, SYP-Seed yield per plant)

Table 5 Path coefficient analysis indicating direct and indirect effects of various traits on yield

| | PH | IL | NFI | NPI | PL | PW | PdL | PBL | SL | SW | TW | LP | NSP | SWt | NPP | NSPl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PH | **-0.073** | -0.013 | 0.023 | -0.006 | -0.012 | 0.006 | -0.012 | 0.004 | -0.017 | 0.009 | -0.034 | 0.009 | 0.036 | -0.071 | 0.014 | -0.026 |
| IL | -0.013 | **-0.073** | 0.059 | -0.003 | -0.008 | -0.058 | 0.029 | -0.007 | -0.005 | -0.006 | 0.038 | 0.009 | 0.034 | 0.081 | -0.072 | 0.158 |
| NFI | -0.015 | -0.038 | **0.113** | 0.001 | 0.009 | -0.036 | -0.025 | -0.002 | -0.002 | -0.010 | 0.055 | 0.001 | -0.016 | 0.121 | -0.244 | 0.563 |
| NPI | 0.018 | 0.008 | 0.003 | **0.024** | 0.028 | -0.053 | 0.036 | -0.005 | 0.022 | -0.034 | 0.048 | 0.018 | 0.077 | 0.106 | -0.167 | 0.138 |
| PL | 0.005 | 0.003 | 0.006 | 0.004 | **0.175** | -0.013 | -0.011 | 0.000 | 0.027 | -0.025 | 0.007 | -0.018 | -0.049 | 0.018 | 0.020 | -0.078 |
| PW | 0.004 | -0.035 | 0.033 | 0.011 | 0.018 | **-0.120** | 0.049 | -0.011 | 0.029 | -0.029 | 0.067 | 0.023 | 0.090 | 0.161 | -0.043 | -0.084 |
| PdL | 0.005 | -0.013 | -0.017 | 0.005 | -0.012 | -0.036 | **0.165** | -0.009 | 0.014 | -0.025 | 0.031 | 0.020 | 0.124 | 0.066 | 0.040 | -0.348 |
| PBL | 0.016 | -0.028 | 0.012 | 0.006 | 0.004 | -0.064 | 0.078 | **-0.020** | 0.018 | -0.013 | 0.085 | 0.013 | 0.052 | 0.184 | -0.042 | 0.020 |
| SL | 0.014 | 0.004 | -0.003 | 0.006 | 0.054 | -0.040 | 0.026 | -0.004 | **0.086** | -0.083 | 0.065 | 0.001 | 0.026 | 0.159 | 0.046 | -0.191 |
| SW | 0.005 | -0.003 | 0.008 | 0.006 | 0.032 | -0.026 | 0.031 | -0.002 | 0.053 | **-0.135** | 0.057 | 0.004 | 0.044 | 0.117 | -0.115 | 0.138 |
| TW | 0.017 | -0.019 | 0.043 | 0.008 | 0.008 | -0.056 | 0.035 | -0.012 | 0.039 | -0.054 | **0.144** | 0.010 | 0.037 | 0.317 | -0.099 | 0.116 |
| LP | 0.013 | 0.014 | -0.003 | -0.009 | 0.065 | 0.056 | -0.068 | 0.005 | -0.002 | 0.011 | -0.031 | **-0.048** | -0.206 | -0.075 | 0.013 | 0.375 |
| NSP | 0.012 | 0.011 | 0.008 | -0.009 | 0.039 | 0.049 | -0.094 | 0.005 | -0.010 | 0.027 | -0.024 | -0.046 | **-0.219** | -0.060 | 0.034 | 0.384 |
| SWt | 0.016 | -0.019 | 0.043 | 0.008 | 0.010 | -0.061 | 0.035 | -0.012 | 0.044 | -0.050 | 0.145 | 0.012 | 0.042 | **0.314** | -0.103 | 0.107 |
| NPP | 0.001 | -0.007 | 0.037 | 0.006 | -0.005 | -0.007 | -0.009 | -0.001 | -0.005 | -0.021 | 0.019 | 0.001 | 0.010 | 0.044 | **-0.735** | 1.512 |
| NSPl | 0.001 | -0.007 | 0.040 | 0.002 | -0.009 | 0.006 | -0.036 | 0.000 | -0.010 | -0.012 | 0.010 | -0.011 | -0.053 | 0.021 | -0.695 | 1.597 |

Residual effect: 0.1413; Diagonal values are direct effects. (PH-Plant height, IL-Inflorescence length, NFI-No. of flowers per inflorescence, NPI-No. of pods per inflorescence, PL-Pod length, PW-Pod width, PdL-Pedicel length, PBL-Pod beak length, SL-Seed length, SW-Seed width, TW-Test weight, LP-Locules per pod, NSP-No. of seeds per pod, Swt-Seed weight, NPP-No. of pods per plant, NSPl-No of seeds per plant) was highly negative, it exerted a very high level of positive indirect effect through no. of seeds/plant to finally increase the rajma yield. The results indicated that the importance should be given to the traits, *viz.* no. of seeds/plant, seed weight, no. of pods/plant, and no. of flowers/inflorescence so that improvement of yield can be efficient.

*Conclusion*

In the present study, rajma bean landraces showed vide variability for all the 17 traits studied. The genotypic variance, phenotypic variance, GCV and PCV, heritability and genetic advance as percent of mean were higher in plant height, no. of pods/plant, no. of seeds/plant, no. of flowers/inflorescence, and seed weight. Correlation studies indicated that the grain yield is highly positively correlated with no. of seeds/plant and no. of pods/plant and test weight. Very high level to high level of direct effects is found in no. of seeds/plant and seed weight. Based on the above findings, it may be concluded that in rajma improvement programmes for increasing the yield, the importance should be given to selection of the traits, viz. no. of flowers/inflorescence, no. of seeds/plant, no of pods/plant, seed weight, and test weight.

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