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Correlations and Path Analysis of Yield Components in Yard Long Bean

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ABSTRACT:An experiment was conducted to study the genetic variability, heritability and genetic advance for yield and yield traits in yard long bean. Four parents and three hybrids of yard long bean were evaluated in a field experiment in randomized block design with three replications during Kharif 2020. Analysis of variance revealed significant differences among the parents and hybrids for most of the characters studied. Yield per plant had significant positive phenotypic and genotypic correlation with pod weight, followed by pods per plant, length of terminal leaf, seeds per pod, pod length, crop duration, keeping quality and days to harvest. Among the various characters, pods per plant exerted the highest positive direct effect on yield per plant.

KEYWORDS:Genotypic correlation, Phenotypic correlation, Pods per plant, Yield per plant, Yard long bean

I. INTRODUCTION

Yard long bean (Vigna unguiculata subsp. sesquipedalis (L.) Verdcourt; 2n=24), a distinct form of cowpea, is one of the most important leguminous vegetable crops originated from Central Africa and widely distributed in India, Indonesia, Philippines and Sri Lanka. It is an annual food legume belonging to the family Fabaceae and the genus Vigna, which comprises of about 80 species. It is called as 'vegetable meat', being a rich and inexpensive source of vegetable protein (3.5 g), calcium (72 mg), iron (2.5 mg), riboflavin (0.09 mg), phosphorus (59 mg) and vitamin A (564 mg 100 g-1 of edible pod) [1]. Cowpea is widely grown in China, South and South East Asia. Because of its quick growth habit and enrichment of soil fertility by fixing atmospheric nitrogen (70 – 240 kg ha-1 of nitrogen year-1), it has become an essential component of sustainable agriculture. Trailing type of vegetable cowpea or yard long bean, vernacularly known as 'Achingapayar', 'Kurutholapayar', 'Vallipayar', 'Pathinettumaniyan' etc., is one of the most popular and remunerative vegetable crops traditionally grown in Kerala, evenly distributed and preferred in all the 14 districts. It is cultivated mainly for crisp and tender pods, which are consumed in cooked form. It is one of the most favourite vegetable crops in Kerala as it ensures a stable market throughout the year.

Correlation analysis is an easy tool providing information that selection for one trait leads to the progress of other positively correlated traits. Correlation helps to evaluate the degree of association between two characters and the viability of indirect selection. The importance of correlation studies in selection programmes is appreciable when highly heritable characters are associated with the important character like yield. Through correlation, breeder is able to estimate the direction of changes expected during selection as well as the strength of the relationships among various traits.

Path coefficient analysis provides a more realistic understanding of the relationship as it partitions the correlation coefficients into direct as well as indirect effects of the variables. Yield is a complex trait; estimation of its direct and indirect association with other traits is inevitable for the improvement of yield. In this study, path analysis was done to understand the genotypic correlation coefficient of yield per plant with length of terminal leaf, pod length, pod weight, pods per plant, seeds per pod, days to harvest, crop duration and keeping quality.

II. MATERIALS AND METHOD

The experiment was laid out in randomized block design with 7 treatments (P1, P2, P3, P4, three hybrids) using the parents, P1 (KAU Deepika), P2 (VellayaniJyothika), P3 (Githika) and P4 (VU 53) in three replications from January-April 2020. One replication consisted of 10 plants planted at a spacing of 1.5 m x 0.45 m with a plot size of 6.75 m^2. Mean performance was studied for the yield characters viz., vine length, at final

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harvest (cm), primary branches per plant, length and breadth of leaflets (cm) and days to first flowering, yield characters like pod length (cm), pod girth (cm), pod weight (g), pods per plant, seeds per pod, hundred seed weight (g), yield per plant (g), yield per plot(kg), days to harvest, crop duration and quality characters like pod protein (%) and keeping quality (% weight loss). The average of five plants were worked out in each replication for statistical analysis**.**

The phenotypic, genotypic and environmental correlation coefficients were computed.

Phenotypic correlation coefficient,

$$r_{Pxy} = \frac{Cov_{P(x,y)}}{\sqrt{V_{P(x)} . V_{P(y)}}}$$

Genotypic correlation coefficient,

$$r_{Gxy} = \frac{Cov_{G(x,y)}}{\sqrt{V_{G(x)} . V_{G(y)}}}$$

The direct and indirect effects of component characters on yield per plant were estimated through path analysis technique.

III. RESULT

Table 1 and 2 represents the phenotypic andgenotypic correlation coefficients between various parameters studied in the experiment.

Yield per plant

Yield per plant had highly significant positive phenotypic correlation with pod weight (0.978), followed by pods per plant (0.977), length of terminal leaf (0.977), seeds per pod(0.938), pod length (0.927), crop duration (0.914), keeping quality (0.768) and days to harvest (0.581). Days to first flowering (-0.967), pod protein (-0.965), pod girth (-0.961), primary branches per plant (-0.961), breadth of terminal leaf (-0.931), vine length (-0.910) and breadth of lateral leaf (-0.590) had significant but negative correlation with yield per plant. Yield per plant showed no significant phenotypic correlation with hundred seed weight (0.151) and length of lateral leaf (-0.410).

Yield per plant expressed highly significant positive genotypic correlation with crop duration (1.009), pods per plant (0.984), pod weight (0.979), length of terminal leaf (0.979), seeds per pod(0.962), pod length (0.928), keeping quality (0.822) and days to harvest (0.594). Days to first flowering (-0.969), Pod protein (-0.966), pod girth (-0.964), primary branches per plant (-0.962), breadth of terminal leaf (-0.937), vine length (-0.917) and breadth of lateral leaf (-0.877) had significant but negative genotypic correlation with yield per plant. Yield per plant showed no significant genotypic correlation with hundred seed weight (0.157) and length of lateral leaf (-0.422).

Vine length

Vine length exhibited highly significant positive phenotypic correlation with pod protein (0.977), pod girth (0.975), primary branches per plant (0.964), breadth of terminal leaf (0.956), breadth of lateral leaf (0.690) and length of lateral leaf (0.666). Length of terminal leaf (-0.955), days to first flowering (-0.930), yield per plant (-0.910), keeping quality (-0.904), crop duration (-0.889), seeds per pod (-0.827), pod weight (-0.822), pods per plant (-0.816), pod length (-0.723) and days to harvest (-0.434) had significant but negative phenotypic correlation with vine length. Hundred seed weight (0.071) had no significant phenotypic correlation with vine length.

Vine length showed a significant positive genotypic correlation for breadth of lateral leaf (1.095), pod girth (0.986), pod protein (0.983), primary branches per plant (0.970), breadth of terminal leaf (0.968) and length of lateral leaf (0.716), while it showed a significant negative association with crop duration (-0.995), keeping quality (-0.970), length of terminal leaf (-0.960), days to first flowering (-0.936), yield per plant (-0.917), seeds per pod (-0.875), pod weight (-0.828), pods per plant (-0.825), pod length (-0.728) and days to harvest (-0.450). Hundred seed weight (-0.073) expressed insignificant correlation with vine length.

Primary branches per plant

Primary branches per plant had highly significant positive phenotypic correlation with pod protein (0.995), followed by pod girth(0.993), breadth of terminal leaf (0.978), vine length (0.964), breadth of lateral leaf (0.696) and length of lateral leaf (0.560). Characters like length of terminal leaf (-0.992), days to first flowering (-0.977), yield per plant (-0.961), seeds per pod (-0.926), crop duration (-0.910), pods per plant (-0.902), pod weight (-0.891), keeping quality(-0.865), pod length (-0.827) and days to harvest (-0.561) had significant but negative phenotypic correlation with primary branches per plant Hundred seed weight (-0.102) had insignificant phenotypic correlation with primary branches per plant.

Primary branches per plant was found to be significant and positively correlated with breadth of lateral leaf (1.041), pod girth(0.996), pod protein (0.995), breadth of terminal leaf

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(0.983) and vine length (0.970) at genotypic level. Primary branches per plant was significantly and negatively correlated with crop duration (-1.014), length of terminal leaf (-0.992), days to first flowering (-0.978), yield per plant (-0.962), seeds per pod (-0.949), keeping quality (-0.920), pods per plant (-0.906), pod weight (-0.892), pod length (-0.827) and days to harvest (-0.572) at genotypic level. Hundred seed weight (-0.104) had no significant genotypic correlation with primary branches per plant

Length of leaflets

Length of terminal leaf exhibited highly significant positive phenotypic correlation with days to first flowering (0.993), yield per plant (0.977), pods per plant (0.928), seeds per pod (0.923), pod weight (0.917), crop duration (0.909), pod length (0.874), keeping quality (0.832) and days to harvest (0.576) whereas negative phenotypic correlation with pod protein (-0.995), primary branches per plant (-0.992), pod girth (-0.991), breadth of terminal leaf (-0.977), vine length(-0.955), breadth of lateral leaf (-0.651) and length of lateral leaf (-0.492). Length of lateral leaf showed a significant positive correlation with breadth of lateral leaf (0.688), vine length (0.666), breadth of terminal leaf (0.607), hundred seed weight (0.578), pod girth (0.569), pod protein (0.566) and primary branches per plant (0.560) while negative correlation with keeping quality (-0.798), crop duration(-0.508), length of terminal leaf (-0.492), seeds per pod (-0.452), days to first flowering (-0.417) and yield per plant (-0.410) at phenotypic level.

Length of terminal leaf showed a significant positive genotypic correlation for crop duration (1.008), days to first flowering (0.994), yield per plant (0.979), seeds per pod (0.952), pods per plant (0.932), pod weight (0.918), keeping quality (0.882), pod length (0.875) and days to harvest (0.588) whereas negative genotypic correlation for pod protein (-0.995), primary branches per plant (-0.992), pod girth (-0.994), breadth of lateral leaf (-0.988), breadth of terminal leaf (-0.982), vine length(-0.960) and length of lateral leaf (-0.514). Length of lateral leaf expressed highly significant positive correlation with breadth of lateral leaf (0.999), keeping quality (0.882),vine length (0.716), breadth of terminal leaf (0.626), hundred seed weight (0.595), days to harvest (0.588), pod girth (0.584) and primary branches per plant (0.580) while negative genotypic correlation for keeping quality (-0.871), crop duration (-0.586), length of terminal leaf (-0.514), seeds per pod (-0.437), days to first flowering (-0.434) and yield per plant (-0.422) at genotypic level.

Breadth of leaflets

Breadth of terminal leaf exhibited highly significant positive phenotypic correlation with pod protein (0.980), primary branches per plant (0.978), pod girth (0.973), vine length (0.956), breadth of lateral leaf (0.721) and length of lateral leaf (0.607), hundred seed weight (0.578) and pod protein (0.566) whereas negative phenotypic correlation with length of terminal leaf (-0.977), days to first flowering (-0.962), yield per plant (-0.931), seeds per pod (-0.916), keeping quality (-0.896), crop duration (-0.879), pods per plant (-0.867), pod weight (-0.851), pod length (-0.780) and days to harvest (-0.438). Breadth of lateral length showed a significant positive phenotypic correlation for breadth of terminal leaf (0.721), primary branches per plant (0.696), vine length (0.690), length of lateral leaf (0.688) and pod protein (0.688) while negative correlation with keeping quality (-0.711), seeds per pod (-0.655), length of terminal leaf (-0.651), crop duration (-0.614), days to first flowering (-0.612), yield per plant (-0.590), pods per plant (-0.497) and pod weight (-0.490) at phenotypic level.

Breadth of terminal leaf showed a significant positive genotypic correlation for breadth of lateral leaf (1.067), pod protein (0.987), primary branches per plant (0.983), pod girth (0.981) and vine length (0.968) whereas significant negative genotypic correlation for length of terminal leaf (-0.988), days to first flowering (-0.967), crop duration (-0.963), seeds per pod (-0.944), yield per plant (-0.937), keeping quality (-0.933), pods per plant (-0.874), pod weight (-0.855), pod length (-0.548) and days to harvest (-0.452). Breadth of lateral leaf expressed highly significant positive genotypic correlation with vine length (1.095), breadth of terminal leaf (1.067), primary branches per plant (1.041), pod protein (1.032), pod girth (1.022) and length of lateral leaf (0.999) while negative correlation with keeping quality (-1.226), length of terminal leaf (-0.988), crop duration (-0.974), days to first flowering (-0.941), seeds per pod (-0.928), pods per plant (-0.749), pod weight (-0.744) and pod length (-0.548) at genotypic level.

Days to first flowering

Days to first flowering had highly significant positive phenotypic correlation with length of terminal leaf (0.993), followed by pods

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per plant (0.923), pod weight (0.909), seeds per pod(0.909), pod length (0.897), crop duration (0.884), keeping quality (0.788) and days to harvest (0.636). Pod protein (-0.981), pod girth (-0.978), primary branches per plant (-0.977), yield per plant (-0.967), breadth of terminal leaf (-0.962), vine length (-0.930) and breadth of lateral leaf (-0.612) exhibited high negative correlation. Days to first flowering showed no significant phenotypic correlation with hundred seed weight (0.252) and length of lateral leaf (-0.417).

Days to first flowering expressed highly significant positive genotypic correlation with length of terminal leaf (0.994), crop duration (0.987), seeds per pod(0.933), pods per plant (0.927), pod weight (0.910), pod length (0.898), keeping quality (0.834) and days to harvest (0.643). Pod protein (-0.982), pod girth (-0.981), primary branches per plant (-0.978), yield per plant (-0.969), breadth of terminal leaf (-0.967), breadth of lateral leaf (-0.941), vine length(-0.936) and length of lateral leaf (-0.434) had significant but negative genotypic correlation with days to first flowering. Days to first flowering showed no significant genotypic correlation with hundred seed weight (0.258).

Pod length

Pod lengthhad highly significant positive phenotypic correlation with pods per plant (0.959), pod weight (0.947), yield per plant (0.927), days to first flowering (0.897), length of terminal leaf (0.874), seeds per pod (0.841), crop duration (0.798) and days to harvest (0.723). Keeping quality (0.508) and hundred seed weight (0.443) had significant positive correlation with pod length at phenotypic level. Characters like pod protein (-0.830), primary branches per plant(-0.827), pod girth (-0.825), breadth of terminal leaf (-0.780) and vine length (-0.723) had significant but negative phenotypic correlation. Length of lateral leaf (-0.056) and breadth of lateral leaf (-0.370) had insignificant phenotypic correlation with pod length.

Pod lengthwas found to be highly significant and positively correlated with pods per plant (0.964), pod weight (0.948), yield per plant (0.928), days to first flowering (0.898), crop duration (0.883), length of terminal leaf (0.875), seeds per pod (0.864) and days to harvest (0.737) at genotypic level. Keeping quality (0.543) and hundred seed weight (0.454) had significant positive genotypic correlation with pod length.Pod lengthwas significantly and negatively correlated with pod protein (-0.830), pod girth (-0.828), primary branches per plant (-0.827), breadth of terminal leaf (-0.784), vine length (-0.728) and breadth of lateral leaf (-0.548). Length of lateral leaf (-0.057) had no significant genotypic correlation with pod length.

Pod girth

Pod girth exhibited highly significant positive phenotypic correlation with pod protein (0.997), primary branches per plant (0.993), vine length (0.975), breadth of terminal leaf (0.973), breadth of lateral leaf (0.697) and length of lateral leaf (0.569). Characters like length of terminal leaf (-0.991), days to first flowering (-0.978), yield per plant (-0.961), crop duration (-0.910), seeds per pod (-0.905), pods per plant (-0.894), pod weight (-0.890), keeping quality (-0.863), pod length (-0.825) and days to harvest (-0.559) had significant but negative correlation with pod girth at phenotypic level. Pod girth showed no significant phenotypic correlation with hundred seed weight (-0.067).

Pod girth showed a significant positive genotypic correlation with breadth of lateral leaf (1.022), pod protein (1.000), primary branches per plant (0.996), yield per plot (0.996), vine length (0.986), breadth of terminal leaf (0.981) and length of lateral leaf (0.584) while it had a significant negative correlation with crop duration (-1.020), length of terminal leaf (-0.994), days to first flowering (-0.981), yield per plant (-0.964), seeds per pod (-0.927), keeping quality (-0.925), pods per plant (-0.899), pod weight (-0.894), pod length (-0.828) and days to harvest (-0.565). Hundred seed weight (-0.080) had insignificant genotypic correlation with pod girth.

Pod weight

Pod weight had highly significant positive phenotypic correlation with pods per plant (0.988), yield per plant (0.978), pod length (0.947), seeds per pod (0.919), length of terminal leaf (0.917), days to first flowering (0.909), crop duration (0.873), keeping quality (0.680) and days to harvest (0.588). Characters like pod protein (-0.895), primary branches per plant (-0.891), pod girth (-0.890), breadth of terminal leaf (-0.851), vine length (-0.822) and breadth of lateral leaf (-0.490) had significant but negative phenotypic correlation. Hundred seed weight (0.157) and length of lateral leaf (-0.279) had insignificant phenotypic correlation with pod weight.

Pod weight was found to be significant and positively correlated with pods per plant (0.994), yield per plant (0.979), crop duration

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(0.956), pod length (0.948), seeds per pod (0.944), length of terminal leaf (0.918), days to first flowering (0.910), keeping quality (0.719) and days to harvest (0.602) at genotypic level. Pod protein (-0.897), pod girth (-0.894), primary branches per plant (-0.892), breadth of terminal leaf (-0.855), vine length (-0.828) and breadth of lateral leaf (-0.744) had significant but negative genotypic correlation. Hundred seed weight (0.161) and length of lateral leaf (-0.286) had no significant genotypic correlation with pod weight.

Pods per plant

Pods per plant exhibited highly significant positive phenotypic correlation with pod weight (0.988), yield per plant (0.977), pod length (0.959), seeds per pod (0.936), length of terminal leaf (0.928), days to first flowering (0.923), crop duration (0.847), keeping quality (0.664) and days to harvest (0.595). Characters like primary branches per plant (-0.902), pod protein (-0.900), pod girth (-0.894), breadth of terminal leaf (-0.867), vine length (-0.816) and breadth of lateral leaf(-0.497) had significant but negative correlation with pods per plant at phenotypic level. Pods per plant showed no significant phenotypic correlation with hundred seed weight (0.238) and length of lateral leaf (-0.270).

Pods per plant showed a significant positive genotypic correlation with pod weight (0.994), yield per plant (0.984), crop duration (0.971), pod length (0.964), seeds per pod (0.956), length of terminal leaf (0.932), days to first flowering (0.927), keeping quality (0.713) and days to harvest (0.610) while it had significant negative correlation with primary branches per plant (-0.906), pod protein (-0.904), pod girth (-0.899), breadth of terminal leaf (-0.874) and breadth of lateral leaf (-0.749). Hundred seed weight (0.248) and length of lateral leaf (-0.277) recorded insignificant genotypic correlation with pods per plant.

Seeds per pod

Seeds per podhad highly significant positive phenotypic correlation with yield per plant (0.938), pods per plant (0.936), length of terminal leaf (0.923), pod weight (0.919), days to first flowering (0.909), pod length (0.841), crop duration (0.812) and keeping quality (0.766). Seeds per podhad significant positive phenotypic correlation with days to harvest (0.498). Characters like primary branches per plant (-0.926), breadth of terminal leaf (-0.916), pod protein(-0.912), pod girth (-0.905), vine length (-0.827), breadth of lateral leaf (-0.655) and length of lateral leaf (-0.452) had significant but negative phenotypic correlation. Hundred seed weight (0.135) had insignificant phenotypic correlation withseeds per pod.

Seeds per podwas found to be highly significant and positively correlated with crop duration (0.965), yield per plant (0.962), pods per plant (0.956), length of terminal leaf (0.952), pod weight (0.944), days to first flowering (0.933), pod length (0.864), keeping quality (0.852) and days to harvest (0.508) at genotypic level. Seeds per podwas significantly and negatively correlated with branches per plant (-0.949), breadth of terminal leaf (-0.944), pod protein (-0.935), breadth of lateral leaf (-0.928), pod girth (-0.927) and vine length (-0.875) at genotypic level. Hundred seed weight (0.147) had no significant genotypic correlation with seeds per pod.

Hundred seed weight

Hundred seed weight had highly significant positive phenotypic correlation with length of lateral leaf (0.578). Days to harvest (0.528) and pod length (0.443) showed significant positive phenotypic correlation with hundred seed weight. All the other characters were found to be insignificant with hundred seed weight at phenotypic level.Hundred seed weight expressed highly significant positive genotypic correlation with length of lateral leaf (0.595) and days to harvest (0.558). Pod length (0.454) showed significant positive genotypic correlation with hundred seed weight. Hundred seed weight had no significant correlation with the other characters at genotypic level.

Days to harvest

Days to harvest exhibited highly significant positive phenotypic correlation with pod length (0.723), days to first flowering (0.636), pods per plant (0.595), pod weight (0.588), yield per plant (0.581) and length of terminal leaf (0.576). Hundred seed weight (0.528), crop duration (0.514) and seeds per pod (0.498) recorded significant positive phenotypic correlation with days to harvest. Primary branches per plant (-0.561), pod girth (-0.559), pod protein (-0.538), breadth of terminal leaf (-0.438) and vine length (-0.434) had significant but negative phenotypic correlation with days to harvest. Length of lateral leaf (0.211) and breadth of lateral leaf (-0.170) had no significant phenotypic correlation with days to harvest.

Days to harvest showed a significant positive genotypic correlation with pod length

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(0.737), days to first flowering (0.643), crop duration (0.619), pods per plant (0.610), pod weight (0.602), yield per plant (0.594), length of terminal leaf (0.588), hundred seed weight (0.558) and seeds per pod (0.508) while it showed a significant negative association with primary branches per plant (-0.572), pod girth (-0.565), pod protein (-0.548), breadth of terminal leaf (-0.452) and vine length (-0.450). Keeping quality (0.248), length of lateral leaf (0.221) and breadth of lateral leaf (-0.287) expressed insignificant correlation with days to harvest.

Crop duration

Crop duration exhibited highly significant positive phenotypic correlation with yield per plant (0.914), length of terminal leaf (0.909), pod weight, (0.873), pods per plant (0.847), keeping quality (0.824) and seeds per pod (0.812). Days to harvest (0.514) was found to be significant and positively correlated with crop duration at phenotypic level. Characters like primary branches per plant (-0.910), pod girth (-0.910), pod protein (-0.908), vine length (-0.889), breadth of terminal leaf (-0.879), breadth of lateral leaf (-0.614) and length of lateral leaf (-0.508) had significant but negative phenotypic correlation with crop duration at phenotypic level. Crop duration showed no significant phenotypic correlation with hundred seed weight (0.039).

Crop duration showed a significant positive genotypic correlation with yield per plant (1.009), length of terminal leaf (1.008), days to first flowering (0.987), pods per plant (0.971), seeds per pod (0.965), pod weight (0.956), pod length (0.883), keeping quality (0.879) and days to harvest (0.619) while it had negative correlation with pod girth (-1.020), pod protein (-1.015), primary branches per plant (-1.014), vine length (-0.995), breadth of lateral leaf (-0.974), breadth of terminal leaf (-0.963) and length of lateral leaf (-0.563). Hundred seed weight (0.043) had insignificant genotypic correlation with crop duration.

Pod protein

Pod protein had highly significant positive phenotypic correlation with vine length (0.977), pod girth (0.997), primary branches per plant (0.995), breadth of terminal leaf (0.980), breadth of lateral leaf (0.688) and length of lateral leaf (0.566). Length of terminal leaf (-0.995), days to first flowering (-0.981), yield per plant (-0.965), seeds per pod(-0.912), crop duration (-0.908), pods per plant (-0.900), pod weight (-0.895), keeping quality (-0.866), pod length (-0.830) and days to harvest (-0.538) had significant but negative correlation with yield per plant. Pod protein showed no significant phenotypic correlation with hundred seed weight (-0.079).

Pod protein exhibited highly significant positive genotypic correlation with breadth of lateral leaf (1.032), pod girth (1.000), primary branches per plant (0.995), breadth of terminal leaf (0.987), vine length (0.983) and length of lateral leaf (0.586). Crop duration (-1.015), length of terminal leaf (-0.995), days to first flowering (-0.982), yield per plant (-0.966), seeds per pod(-0.935), keeping quality (-0.926), pods per plant (-0.904), pod weight (-0.897), pod length (-0.830) and days to harvest (-0.548) had significant but negative genotypic correlation with pod protein. Pod protein showed no significant phenotypic correlation with hundred seed weight (-0.081).

Keeping quality

Keeping quality had highly significant positive phenotypic correlation with length of terminal leaf (0.832), crop duration (0.824), days to first flowering (0.788), yield per plant (0.768), seeds per pod (0.766), pod weight (0.680), pods per plant (0.664) and pod length (0.508).Characters like vine length (-0.904), breadth of terminal leaf (-0.896), pod protein (-0.866), primary branches per plant (-0.865), pod girth (-0.863), length of lateral leaf (-0.798) and breadth of lateral leaf (-0.711) had significant but negative phenotypic correlation. Days to harvest (0.223) and hundred seed weight (-0.262) had insignificant phenotypic correlation withkeeping quality.

Keeping quality was found to be significant and positively correlated with crop duration (0.879), length of terminal leaf (0.882), seeds per pod(0.852), days to first flowering (0.834), yield per plant (0.822), pod weight (0.719), pods per plant (0.713) and pod length (0.543) at genotypic level. Keeping quality was significantly and negatively correlated with breadth of lateral leaf (-1.226), vine length (-0.970), breadth of terminal leaf (-0.933), pod girth (-0.925), primary branches per plant (-0.920) and length of terminal leaf (-0.871) at genotypic level. Days to harvest (0.248) and hundred seed weight (-0.291) had no significant genotypic correlation with keeping quality.

PATH COEFFICIENT ANALYSIS

Among the various characters, pods per plant (0.361) exerted the highest positive direct effect on yield per plant followed by length of terminal leaf (0.312), days to harvest (0.228), crop

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duration (0.116) and pod weight (0.099), while pod length (-0.025), seeds per pod (-0.410) and keeping quality (-0.504) expressed negative direct effect on yield per plant (Table 3).

The indirect effect of length of terminal leaf was positive pod weight (0.007). The negative indirect effect was through pod length (-0.011), crop duration (-0.117), days to harvest (-0.223), pods per plant (-0.323), seeds per pod (-0.410) and keeping quality (-0.501).Pod length exerted positive indirect effect through length of terminal leaf (0.141) and it was negative through pods per plant (-0.035), crop duration (-0.042), days to harvest (-0.080), keeping quality (-0.186) and pod weight (-0.191).

Pod weight positively influenced yield per plant indirectly through pods per plant (0.131), length of terminal leaf (0.023) and crop duration (0.003) and negatively through keeping quality (-0.003), pod length (-0.018) and seeds per pod (-0.039).Pods per plant had positive indirect effects through keeping quality (0.468), seeds per pod (0.361), days to harvest (0.212), crop duration (0.112), pod weight (0.035) and pod length (0.002). The negative indirect effect was through length of terminal leaf (-0.278).

The indirect effect of seeds per pod was positive indirect through length of terminal leaf (0.312) and pod weight (0.009). The negative indirect effect was through pod length (-0.012), crop duration (-0.116), days to harvest (-0.222), pods per plant (-0.317) and keeping quality (-0.499).Days to harvest exhibited positive indirect effect through keeping quality (0.502), pods per plant (0.336), seeds per pod (0.310), crop duration (0.115), pod length (0.009) and pod weight (0.001). It was negative through length of terminal leaf (-0.306).

Crop duration exerted positive indirect effect through keeping quality (0.516), seeds per pod (0.412), pods per plant (0.350), days to harvest (0.226), pod length (0.009) and pod weight (0.003) and it was negative through length of terminal leaf (-0.315).Keeping quality had positive indirect effects through length of terminal leaf (0.310) and pod weight (0.001). The negative indirect effects were through pod length (-0.009), crop duration (-0.118), days to harvest (-0.227), pods per plant (-0.335) and seeds per pod (-0.406). The residual effect obtained was 0.001.

IV. DISCUSSION

Yield per plant had significant positive phenotypic correlation with pod weight, followed by pods per plant, length of terminal leaf, seeds per pod, pod length, crop duration, keeping quality and days to harvest. Yield per plant showed no significant phenotypic correlation with hundred seed weight and length of lateral leaf. Yield per plant expressed significant positive genotypic correlation with crop duration, pods per plant, length of terminal leaf, pod weight, seeds per pod, pod length, keeping quality and days to harvest, which is in agreement with Lovely and Radhadevi (2006) and Ullah et al. (2011). Yield per plant showed no significant genotypic correlation with hundred seed weight and length of lateral leaf. Positive correlation of yield per plant with pods per plant was noticed by Resmi (1998), Ajith (2001) and Philip (2004) in cowpea. Positive association between yield per plant and seeds per pod was given by Huqueet al. (2012) and Madhavi (2012). Days to fifty per cent flowering had significant positive correlation with pod length, number of seeds per pod, days to maturity and hundred seed weight (Selvakumar and Ushakumari, 2013).

Pod lengthhad significant positive phenotypic and genotypic correlation with pods per plant, pod weight, yield per plant, days to first flowering, length of terminal leaf, seeds per pod, crop duration and days to harvest. Pods per plant exhibited highly significant positive phenotypic and genotypic correlation with pod weight, yield per plant, pod length, seeds per pod, length of terminal leaf, days to first flowering, crop duration, keeping quality and days to harvest. Pod weight showed no significant phenotypic and genotypic correlation with hundred seed weight and length of lateral leaf.

Seeds per podwas found to be significant and positively correlated with crop duration, yield per plant, pods per plant, length of terminal leaf, pod weight, days to first flowering, pod length, keeping quality and days to harvest at phenotypic and genotypic level which is in line with the findings of Santos et al. (2014). Hundred seed weight had no significant phenotypic and genotypic correlation with most of the traits. According to Annasaheb (2013), seed yield per plant expressed strong significant positive genotypic and phenotypic correlation with number of pods per plant, harvest index, number of seeds per pod, pod length and plant height at maturity. Crop duration exhibited significant positive phenotypic and genotypic correlation with yield per plant, length of terminal leaf, pod weight, pods per plant, keeping quality and seeds per pod.

Pod protein expressed significant positive phenotypic and genotypic correlation with breadth

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of lateral leaf, pod girth, yield per plot, primary branches per plant, breadth of terminal leaf, vine length and length of lateral leaf. Keeping quality had highly significant positive phenotypic and genotypic correlation with length of terminal leaf, crop duration, days to first flowering, yield per plant, seeds per pod, pod weight, pods per plant and pod length.

Among the various characters, pods per plant exerted the highest positive direct effect on yield per plant followed by length of terminal leaf, days to harvest, crop duration and pod weight while pod length, seeds per pod and keeping quality expressed negative direct effect on yield per plant. Selvakumar and Ushakumari (2013) reported that pod weight had positive and high direct effect on grain yield. The variable number of seeds per pod had direct negative effect with the variable yield per plant, which is in agreement with the results reported by Ullah et al. (2011) and Santos et al. (2014).

Pod length positively influenced yield per plant indirectly through length of terminal leaf. The negative direct effect of pod length on yield observed, conforms with the findings of Panicker (2000), Bastian et al. (2001) and Neema and Palanisamy (2001). The indirect effect of pod weight was positive through pods per plant, length of terminal leaf, crop duration and days to harvest. Pods per plant exhibited positive indirect effect through keeping quality, seeds per pod, days to harvest, crop duration, pod weight and pod length, which is in agreement with Shankoet al. (2014).

The component of residual effect of path analysis was 0.001, the low residual effect indicated that characters for path analysis were adequate and appropriate. Among the different traits, pods per plant could be considered as the most important trait for enhancing the yield in yard long bean because of its high, positive correlation and direct effect with yield per plant along with high heritability and genetic advance. This is in conformity with Ullah et al. (2011), who reported maximum direct positive effect of pods per plant with pod yield in cowpea.

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Table 1. Phenotypic correlation coefficients among eighteen characters

Characters	YPP	VL	PBPP	LTL	LLL	BTL	BLL	PL	PG
YPP	1.000	-0.910**	-0.961**	0.977**	-0.410	-0.931**	-0.590**	0.927**	-0.961**
VL	-0.910**	1.000	0.964**	-0.955**	0.666**	0.956**	0.690**	-0.723**	0.975**
PBPP	-0.961**	0.964**	1.000	-0.992**	0.560**	0.978**	0.696**	-0.827**	0.993**
LTL	0.977**	-0.955**	-0.992**	1.000	-0.492*	-0.977**	-0.651**	0.874**	-0.991**
LLL	-0.410	0.666**	0.560**	-0.492*	1.000	0.607**	0.688**	-0.056	0.569**
BTL	-0.931**	0.956**	0.978**	-0.977**	0.607**	1.000	0.721**	-0.780**	0.973**
BLL	-0.590**	0.690**	0.696**	-0.651**	0.688**	0.721**	1.000	-0.370	0.697**
PL	0.927**	-0.723**	-0.827**	0.874**	-0.056	-0.780**	-0.370	1.000	-0.825**
PG	-0.961**	0.975**	0.993**	-0.991**	0.569**	0.973**	0.697**	-0.825**	1.000
PW	0.978**	-0.822**	-0.891**	0.917**	-0.279	-0.851**	-0.490*	0.947**	-0.890**
PPP	0.977**	-0.816**	-0.902**	0.928**	-0.270	-0.867**	-0.497*	0.959**	-0.894**
SPP	0.938**	-0.827**	-0.926**	0.923**	-0.452*	-0.916**	-0.655**	0.841**	-0.905**
HSW	0.151	0.071	-0.102	0.166	0.578**	-0.088	0.228	0.443*	-0.067
DOF	-0.967**	-0.930**	-0.977**	0.993**	-0.417	-0.962**	-0.612**	0.897**	-0.978**
DTH	0.581**	-0.434*	-0.561**	0.576**	0.211	-0.438*	-0.170	0.723**	-0.559**
CD	0.914**	-0.889**	-0.910**	0.909**	-0.508*	-0.879**	-0.614**	0.798**	-0.910**
P	-0.965**	0.977**	0.995**	-0.995**	0.566**	0.980**	0.688**	-0.830**	0.997**
KQ	0.768**	-0.904**	-0.865**	0.832**	-0.798**	-0.896**	-0.711**	0.508*	-0.863**

* Significant at 5 percent level ** Significant at 1 percent level

YPP- Yield per plant; VL-Vine length (cm); PBPP-Primary branches per plant; LTL- Length of terminal leaf; LLL- Length of lateral leaf; BTL- Breadth of terminal leaf ;BLL- Breadth of lateral leaf;PL-Pod length (cm); PG-Pod girth; PW-Pod weight (g); PPP-Pods per plant; SPP-Seeds per pod; HSW-Hundred seed weight (g); DOF-Days to first flowering; DTH-Days to harvest; CD-Crop duration; P- Pod protein (%); KQKeeping quality

Table 1. Phenotypic correlation coefficients among eighteen characters (continue)

Characters	PW	PPP	SPP	HSW	DOF	DTH	CD	P	KQ
YPP	0.978**	0.977**	0.938**	0.151	-0.967**	0.581**	0.914**	-0.965**	0.768**
VL	-0.822**	-0.816**	-0.827**	0.071	-0.930**	-0.434*	-0.889**	0.977**	-0.904**
PBPP	-0.891**	-0.902**	-0.926**	-0.102	-0.977**	-0.561**	-0.910**	0.995**	-0.865**

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LTL	0.917**	0.928**	0.923**	0.166	0.993**	0.576**	0.909**	-0.995**	0.832**
LLL	-0.279	-0.270	-0.452*	0.578**	-0.417	0.211	-0.508*	0.566**	-0.798**
BTL	-0.851**	-0.867**	-0.916**	-0.088	-0.962**	-0.438*	-0.879**	0.980**	-0.896**
BLL	-0.490*	-0.497*	-0.655**	0.228	-0.612**	-0.170	-0.614**	0.688**	-0.711**
PL	0.947**	0.959**	0.841**	0.443*	0.897**	0.723**	0.798**	-0.830**	0.508*
PG	-0.890**	-0.894**	-0.905**	-0.067	-0.978	-0.559**	-0.910**	0.997**	-0.863**
PW	1.000	0.988**	0.919**	0.157	0.909**	0.588**	0.873**	-0.895**	0.680**
PPP	0.988**	1.000	0.936**	0.238	0.923**	0.595**	0.847**	-0.900**	0.664**
SPP	0.919**	0.936**	1.000	0.135	0.909**	0.498*	0.812**	-0.912**	0.766**
HSW	0.157	0.238	0.135	1.000	0.252	0.528*	0.039	-0.079	-0.262
DOF	0.909**	0.923**	0.909**	0.252	1.000	0.636**	0.884**	-0.981**	0.788**
DTH	0.588**	0.595**	0.498*	0.528*	0.636**	1.000	0.514*	-0.538*	0.223
CD	0.873**	0.847**	0.812**	0.039	0.884**	0.514*	1.000	-0.908**	0.824**
P	-0.895**	-0.900**	-0.912**	-0.079	-0.981**	-0.538*	-0.908**	1.000	-0.866**
KQ	0.680**	0.664**	0.766**	-0.262	0.788**	0.223	0.824**	-0.866**	1.000

* Significant at 5 percent level ** Significant at 1 percent level

Table 2. Genotypic correlation coefficients among eighteen characters

Characters	YPP	VL	PBPP	LTL	LLL	BTL	BLL	PL	PG
YPP	1.000	-0.917**	-0.962**	0.979**	-0.422	-0.937**	-0.877**	0.928**	-0.964**
VL	-0.917**	1.000	0.970**	-0.960**	0.716**	0.968**	1.095**	-0.728**	0.986**
PBPP	-0.962**	0.970**	1.000	-0.992**	0.580**	0.983**	1.041**	-0.827**	0.996**
LTL	0.979**	-0.960**	-0.992**	1.000	-0.514*	-0.982**	-0.988**	0.875**	-0.994**
LLL	-0.422	0.716**	0.580**	-0.514*	1.000	0.626**	0.999**	-0.057	0.584**
BTL	-0.937**	0.968**	0.983**	-0.982**	0.626**	1.000	1.067**	-0.784**	0.981**
BLL	-0.877**	1.095**	1.041**	-0.988**	0.999**	1.067**	1.000	-0.548*	1.022**
PL	0.928**	-0.728**	-0.827**	0.875**	-0.057	-0.784**	-0.548*	1.000	-0.828**
PG	-0.964**	0.986**	0.996**	-0.994**	0.584**	0.981**	1.022**	-0.828**	1.000
PW	0.979**	-0.828**	-0.892**	0.918**	-0.286	-0.855**	-0.744**	0.948**	-0.894**
PPP	0.984**	-0.825**	-0.906**	0.932**	-0.277	-0.874**	-0.749**	0.964**	-0.899**
SPP	0.962**	-0.875**	-0.949**	0.952**	-0.437*	-0.944**	-0.928**	0.864**	-0.927**
HSW	0.157	0.073	-0.104	0.169	0.595**	-0.098	0.232	0.454*	-0.080
DOF	-0.969**	-0.936**	-0.978**	0.994**	-0.434*	-0.967**	-0.941**	0.898**	-0.981**
DTH	0.594**	-0.450*	-0.572**	0.588**	0.221	-0.452*	-0.287	0.737**	-0.565**

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CD	1.009**	-0.995**	-1.014**	1.008**	-0.563**	-0.963**	-0.974**	0.883**	-1.020**
P	-0.966**	0.983**	0.995**	-0.995**	0.586**	0.987**	1.032**	-0.830**	1.000**
KQ	0.822**	-0.970**	-0.920**	0.882**	-0.871**	-0.933**	-1.226**	0.543*	-0.925**

* Significant at 5 percent level ** Significant at 1 percent level

Table 2. Genotypic correlation coefficients among eighteen characters (continue)

Characters	PW	PPP	SPP	HSW	DOF	DTH	CD	P	KQ
YPP	0.979**	0.984**	0.962**	0.157	-0.969**	0.594**	1.009**	-0.966**	0.822**
VL	-0.828**	-0.825**	-0.875**	0.073	-0.936**	-0.450	-0.995**	0.983**	-0.970**
PBPP	-0.892**	-0.906**	-0.949**	-0.104	-0.978**	-0.572**	-1.014**	0.995**	-0.920**
LTL	0.918**	0.932**	0.952**	0.169	0.994**	0.588**	1.008**	-0.995**	0.882**
LLL	-0.286	-0.277	-0.437*	0.595**	-0.434*	0.221	-0.563**	0.586**	-0.871**
BTL	-0.855**	-0.874**	-0.944**	-0.098	-0.967**	-0.452*	-0.963**	0.987**	-0.933**
BLL	-0.744**	-0.749**	-0.928**	0.232	-0.941**	-0.287	-0.974**	1.032**	-1.226**
PL	0.948**	0.964**	0.864**	0.454*	0.898**	0.737**	0.883**	-0.830**	0.543*
PG	-0.894**	-0.899**	-0.927**	-0.080	-0.981**	-0.565**	-1.020**	1.000**	-0.925**
PW	1.000	0.994**	0.944**	0.161	0.910**	0.602**	0.956**	-0.897**	0.719**
PPP	0.994**	1.000	0.956**	0.248	0.927**	0.610**	0.971**	-0.904**	0.713**
SPP	0.944**	0.956**	1.000	0.147	0.933**	0.508**	0.965**	-0.935**	0.852**
HSW	0.161	0.248	0.147	1.000	0.258	0.558**	0.043	-0.081	-0.291
DOF	0.910**	0.927**	0.933**	0.258	1.000	0.643**	0.987**	-0.982**	0.834**
DTH	0.602**	0.610**	0.508**	0.558**	0.643**	1.000	0.619**	-0.548*	0.248
CD	0.956**	0.971**	0.965**	0.043	0.987**	0.619**	1.000	-1.015**	0.879**
P	-0.897**	-0.904**	-0.935**	-0.081	-0.982**	-0.548*	-1.015**	1.000	-0.926**
KQ	0.719**	0.713**	0.852**	-0.291	0.834**	0.248	0.879**	-0.926**	1.000

* Significant at 5 percent level ** Significant at 1 percent level

Table 3. Direct and indirect effects of eight components characters on yield per plantin yard long bean

	LTL	PL	PW	PPP	SPP	DTH	CP	KQ
LTL	0.312	0.141	0.023	-0.279	0.312	-0.306	-0.315	0.310
PL	-0.011	-0.025	-0.018	0.002	-0.012	0.009	0.009	-0.009

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PW	0.007	0.070	0.099	0.035	0.009	0.001	0.003	0.001
PPP	-0.323	-0.035	0.131	0.361	-0.317	0.336	0.350	-0.335
SPP	-0.410	-0.191	-0.039	0.361	-0.410	0.310	0.412	-0.406
DTH	-0.223	-0.080	0.001	0.212	-0.222	0.228	0.226	-0.227
CP	-0.117	-0.042	0.003	0.112	-0.116	0.115	0.116	-0.118
KQ	-0.501	-0.186	-0.003	0.468	-0.499	0.502	0.516	-0.504

Residual effect = 0.001
Values on principal diagonal elements indicate direct effects; Values on off diagonal elements indicate indirect effects
LTL-Length of terminal leaf (cm); PL- Pod length (cm); PW- Pod weight (g); PPP- Pods per plant; SPP- Seeds per pod;
DTH- Days to harvest; CP- Crop duration (g); KQ- Keeping quality