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Research Article

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Agro-morphological characterization of pole-type common bean (*Phaseolus vulgaris* L.) cultivars in mid-hill of Nepal

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ABSTRACT
An experiment was conducted on Pole type cultivars of bean during May-July, 2015 at IAAS, Lamjung, Nepal. RCB design using 7 cultivar as treatments were laid out in 3 replicates. The genotypes used were: LB-31, Madhav, LB-37, Chinese Long, Chaumasa, Trishuli and LB-39. Observations were made on agro-morphological descriptors of bean, namely – Days to seedling emergence, internodal length, number of branches on main stem, length of the petiole, insect damage score at 60th day, leaf area, seed color, seed length and flower color. 5 plant samples were drawn from net plot of 3.2m constituting 12.5% of total population for measurement of attributes. Chemical fertilizer was used at the rate of $N:P_2O_5:K_2O$ = 4:6:3 kg per ropani, based on a blanket recommendation by national government. The field with standing crop was intercultured by weeding and earthing up twice over the entire season. Among the cultivars, Chinese Long showed the earliest emergence (5 days) in comparison to LB-39 (7 days) cultivar. In absence of any form of insect management practices, all cultivars showed some form of vegetative damage – average score being 4.05 (with 10 being the maximum in 1-10 scale scoring of foliar damage), and maximum (6.08) damage exhibited by LB-31. Chinese Long's combination of early emergence, vigorous canopy (large leaves) and relatively low insect damage suggests it is well-suited for rapid establishment and vigorous growth in the mid-hills. In contrast, LB-39's very long internodes, twining habit and large seeds suggest it is ideal for use as pole-bean.
Keywords: Descriptors, Phenotyping, Leaf Area Index, Growth Determinacy

INTRODUCTION
Common bean (*Phaseolus vulgaris* L.) is an important grain legume with considerable morphological and genetic diversity (Broughton et al., 2003). It derives from two main domestication gene pools (Andean and Mesoamerican) and has been widely dispersed, resulting in many landraces (Blair et al., 2010). On the basis of growth habit, there are two types of French bean -- Pole type or climbing type and Dwarf type or bush type. In Nepal, common bean is the most widely cultivated pulse, grown from lowland plains to high hills. A significant proportion of domestic production come from Karnali Province (including Dailekh and Jumla districts), while there is growing trend in it's cultivation in Mid-hill districts of western region of Nepal (MoALD, 2023). Pole (indeterminate, climbing) bean cultivars are particularly popular in Nepal's maize–bean intercropping systems, as they can use maize stalks for support (Singh, 1982). Despite this diversity, Nepal's average bean yield remains well below those in developed production systems (MoALD, 2023).
Domesticated beans may have arisen due to selection for few but large effect genes that are tied to expression of traits such as growth type and phenology (Koinage, 1996). Due to high variability within the Phaseolus family, genetic improvement by classical breeding has been quite successful, one of the aspects being plant architecture (Singh, 1999). Morphological and agronomic descriptors remain key for preliminary germplasm characterisation (Singh, 2001; IPGRI, 1992). Recent studies have documented agro-morphological variability in Nepalese bean germplasm (e.g. Chhetri and Bhatta, 2017; Pandey et al., 2012), but they did not focus on specific pole-type cultivars under mid-hill conditions. The present study fills that gap. It aims to characterise seven pole-type common bean cultivars commonly occurring around Gandaki Province (Western region) in Lamjung, Nepal (subtropical mid-hills), under upland maize-based cropping. The specific objective was to evaluate variation among these cultivars using agro-morphological descriptors under field conditions.

MATERIALS AND METHODS
A field experiment was conducted at the IAAS, Lamjung upland research farm. The design was RCB with 3 blocks and 7 treatments (cultivars: LB-31, Madhav, LB-37, Chinese Long, Chaumasa, Trishuli and LB-39). Fertility

gradient was known from previous studies, to be unidirectional. Hence individual blocks were laid perpendicular to the direction of fertility gradient of the field. Each gross plot measured 4.0m x 2.4m (9.6m^2), with four rows spaced at 1.0m. Within each row, plants were spaced at 0.4 m (6 plants per row). Two seeds were sown per spot and thinned to one seedling. A central 3.2 m^2 net plot (excluding border rows) was used for data collection. Fertilizer (basal) was applied at N:P_2O_5:K_2O = 4:6:3 kg per ropani (1/20th of a hectare), plus goat manure. Weeding was done at 15 and 50 days after sowing (DAS); standard agronomic practices were followed otherwise.

Data were collected from representative plants (4 plants per net plot, i.e., 12.5% of the stand). Emergence: Days to emergence (DTE) was recorded as days from sowing until the seedling emerged. Vegetative traits (30 DAS): On each sampled plant, 2nd - 3rd internode length (INL, cm), number of branches on the main stem (NBMS), and length of the longest petiole (LLP, cm) from trifoliate leaves. Leaf area per plant (LA, cm^2) was obtained by summing the area of all leaves (computed via measurement of length and average widths, taken at 3 regions – tip, middle and base along length). Insect damage (60 DAS): Damage to foliage was recorded on 1-10 scale (1 = no damage, 10 = severe damage) following IBPGR (1982) guidelines.

Statistical analysis: ANOVA was performed using R (R Core Team, 2022) with both cultivar as well as block effects as fixed. Tukey's HSD (Tukey's B) at $p = 0.05$ was used for mean separation. In the tables below, means sharing the same letter are not significantly different. Traits with non-significant cultivar effects (in ANOVA) are noted as such in the text.

RESULTS AND DISCUSSION

Days to Emergence

Rapid emergence is advantageous for crop establishment. In beans, rapid and uniform germination is a desirable trait. For example, de Ron et al. (2016) found genotypes with stress-tolerant early emergence had higher yield potential. Thus Chinese Long's early germination likely contributes to its vigorous start, whereas slower emergence of LB-39 could be a disadvantage in suboptimal conditions. The average of number of days to emergence among all the cultivars was 6.05 days. Dormancy, innate, rather than imposed, and moisture uptake rate of seed define the earliness of seedling emergence, which may occur as an important source of variation among populations (Andersson et al., 1997).

Internode Length

Internode length varied strongly. LB-39 cultivar had by far the longest internode (7.3cm), significantly exceeding all others (next highest 4.5 cm in Chinese Long). Chinese Long, LB-31 and LB-37 were intermediate (4.0-4.5 cm), while Trishuli, Madhav, Chaumase had the shortest (2.1- 3.0 cm). Longer internodes contributes to greater vine height and twining ability. Internode length is a key determinant of plant architecture; bean genotypes with elongated internodes are better climbers, which is important for pole-bean performance. No previous Nepali study has reported such extreme internode differences, highlighting LB-39's distinct architecture.

Number of Branches in Main Stem

Mean branches on the main stem at 30 DAS was 6.86. Chinese Long tended to have the most (7.75) and LB-39 the fewest (5.50), but differences were small. ANOVA showed no significant cultivar effect (Table 1). This suggests similar early-branching potential among these cultivars. Branch number often reflects a strong genotype x environment interaction (Pandey, 2011). Our early growth stage measurement may not capture final branching differences. In any case, branch number did not distinguish these cultivars at 30 DAS, which is similar in idea to that reported by Kandel (2010). Contrarily, however, Alghamdi (2007) reported, among other traits, that the genotypes differed significantly for number of branches per plant.

Petiole Length

The longest petiole length occurred in Chaumasa (10 cm), in comparison to shortest of LB-39 (8.01 cm). Average of the petiole length across the cultivars subject was 8.99 cm. Petiole length was not significantly different among the cultivars. Thus, LLP is not a useful discriminator here.

Leaf Area

Maximum area of leaf was found in Chaumasa cultivar (270.14 cm²), while the minimum of 198.76 cm² was observed in LB-39 cultivar. Although a significant variation could not be established among the cultivars, the average leaf-area size for the entirety of the sample values to 252.66 cm². Makeen et al. (2007) reported on yield of mungbean as being correlated with leaf area index (LAI).

Insect Damage Scoring at 60th day

Insect damage scoring at 60th day after sowing of seed showed the presence of significant variability among cultivars indicative of vulnerability to physical damage of vegetative parts from the insect pests. Almost all of the cultivars showed some form of mild to lower severity in damage (Average of mean value = 4.05). Highest damage score of 6.083 was recorded for LB-31 cultivar. All other cultivars exhibited significantly lower level of damage.

A brief survey of Nepalese bean germplasm shows presence of 4 distinct and recurring coat color and pattern, i.e., brown, black, mottled brown, and white. Genotypes with Liliac flowers exclusively produced black colored seeds. Most genotypes with white flowers, on the other hand, produced brown or white seeds. LB-39, a white seeded cultivar, produced white flowers. LB-31 cultivar had purple flower. Similarly, Trishuli, with its brown seeds produced white colored flowers. The average major diameter of (elliptical) seed was found to be highest in LB-39 (1.306 cm) and lowest in LB-31 (1.113 cm).

Qualitative appraisal of flower colour, showed distinctiveness. LB-31 had purple flowers; Madhav, Chinese Long and Chaumasa had lilac; LB-37, Trishuli and LB-39 had white. Seed coat colour also varied: four major types appeared (black, brown, mottled, white; Table 2). Notably, all lilac-flowered cultivars produced black seeds, whereas white-flowered ones produced brown or white seeds. For example, Madhav, Chinese Long and Chaumasa (lilac flowers) all had black seeds, while LB-39 (white flower) had white seeds, and LB-31 (purple flower) had light-brown mottled seeds. This association agrees with earlier reports: Pandey et al. (2011) observed that lilac-flowered beans in Nepal produced black seeds, whereas white flowers were linked to brown/white seeds. Similarly, Stoilova et al. (2005) noted variability in bean seed colour linked to flower colour. Flower colour genetics is complex (multiple complementary genes for purple pigmentation), but our results fit known patterns.

Chinese Long's combination of early emergence, vigorous canopy (large leaves) and relatively low insect damage suggests it is well-suited for rapid establishment and vigorous growth in the mid-hills. In contrast, LB-39's very long internodes, twining habit and large seeds suggest it is ideal for pole-bean use (e.g. climbing on maize stalks) despite its slower emergence. Maize–bean intercropping is common in Nepal, and climbing beans that utilize maize support can enhance system productivity. Trishuli and Chinese Long, with lower pest damage, could be preferable where pest pressure is a concern. These trait combinations also indicate breeding potential: for example, crossing Chinese Long's earliness and vigour with LB-39's climbing traits could combine desirable features. In general, our findings echo other diversity studies: high phenotypic variability in bean germplasm provides a pool of traits for breeding.

Table 1. Mean values of quantitative descriptors for seven common bean cultivars

Cultivar	INL	NBMS	LLP	DTE	IDS	LA
LB-31	4.00[ab]	7.17	8.67	6.00[abc]	6.08[b]	263.20
Madhav	2.43[a]	7.08	9.58	5.67[ab]	3.83[a]	257.50
LB-37	4.04[ab]	7.17	9.10	6.00[abc]	3.67[a]	252.77
Chinese Long	4.50[ab]	7.75	8.75	5.00[a]	3.50[a]	319.49
Chaumasa	2.06[a]	6.92	10.00	6.00[abc]	3.83[a]	270.14
Trishuli	2.99[a]	6.42	8.83	6.67[bc]	3.33[a]	206.75
LB-39	7.30[b]	5.50	8.01	7.00[c]	4.08[a]	198.76
F-test	*	NS	NS	*	*	NS
Grand Mean	3.90	6.86	8.99	6.05	4.05	252.66
SE	0.303	0.205	0.245	0.103	0.124	10.96
CV	35.6	13.73	12.46	11.85	14.10	19.89

2nd to 3rd internodal length (INL), number of branches on main stem (NBMS), length of longest petiole (LLP), days to emergence (DTE), insect damage scoring at 60th day (IDS) and leaf area (LA). Mean separation (using Tukey's B test) in columns followed by the different letter(s) are significantly different at $p = 0.05$ level of significance.

Table 2. Flower attributes (categorical) and major-axis seed diameter (numerical) of cultivars

Cultivar	Flower color	Seed color	Seed diameter (cm)
LB-31	Purple	Mottled light brown with dark spots	1.113
Madhav	Liliac	Black	1.142
LB-37	White	Brown	1.219
Chinese Long	Liliac	Black	1.125
Chaumasa	Liliac	Black	1.175
Trishuli	White	Light Brown	1.123
LB-39	White	White	1.305

CONCLUSION

In conclusion, this study highlights appreciable variation in pole-type bean cultivars under mid-hill conditions. Chinese Long combines early emergence and vigorous growth, making it a strong candidate for upland cultivation. LB-39's long vines and larger seeds suit it for pole-bean and maize-intercrop use, despite slower emergence. Cultivars like Trishuli, which showed lower insect damage, offer tolerance advantages. Such trait differences, identified using simple descriptors, can guide selection of parental lines and inform cultivar recommendations. This work thereby contributes to inform use of local genetic diversity by identifying divergent genotypes, in common bean improvement.

CONFLICT OF INTEREST

The author here declares there is no conflict of interest in the publication of this article.

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