**Varietal Evaluation in Kidney Bean (*Phaseolus vulgaris* L.)**

**ABSTRACT**

Kidney bean (*Phaseolus vulgaris* L.), locally known as Rajma, is popular from the Terai to the Hills of Nepal. Its current national productivity is low (1.2 t/ha) and stagnant due to the limited availability of high-yielding varieties, inappropriate sowing times, and suboptimal agronomic practices. To address this gap and identify promising genotypes for varietal release, a series of multi-year trials were conducted during the winters of 2022/23 and 2023/24 in the Grain Legumes Research Program (GLRP), Khajura, Banke, Nepal. These trials included an Observation Nursery (OBN) with 24 genotypes, a Coordinated Varietal Trial (CVT) with 12 genotypes, and a Participatory Varietal Selection (PVS) trial with 5 genotypes. The trials revealed genotypic variability in key agronomic traits including flowering and maturity duration, plant height, pod number, and seed weight. The results from the OBN indicated that PDR-14, Ramechhap#2, and COLL#14 were the highest yielders in 2022/23, while PDR-14 and COLL#3 performed best in 2023/24. In CVT, Chitra showed the consistently highest seed yield (2037–2762 kg/ha) in both the years 2022/23 and 2023/24. In the combined result, Chitra recorded the highest seed yield (2399 kg/ha), followed by PDR-14 (2193 kg/ha) and Panta-2 (1988 kg/ha). Under PVS, Arun-2 achieved the highest combined seed yield (3205 kg/ha), indicating its superior productivity and adaptability. Similarly, Utkarsh and Ambar also performed well, producing 3062 and 2802 kg/ha, respectively. The consistent performance of genotypes like PDR-14, Arun-2, Chitra, and Amber in both years indicated them as candidate varieties for release for general cultivation to enhance the production and productivity of kidney bean in Nepal.

**Keywords:** Kidney bean, variety, yield, OBN, CVT, PVS

**INTRODUCTION**

The legume crops play a vital role in Nepalese agricultural systems, serving as key sources of protein, income, and soil fertility improvement. They occupy approximately 11% of the country's total cultivated land, ranking fourth in both area and production after rice, maize, and wheat (MoALD, 2023). Grain legumes are cultivated in 334550 ha with a production and productivity of 408371 t and 1220 kg/ha (MoALD, 2023). The limited cultivated areas and production of the grain legumes contribute about 9.4% or more than NRs 15 billion of the total import value of the agricultural commodities, and has caused a heavy drain of scare foreign exchange in the country (Pokhrel *et al.,* 2018; DoC, 2023). There is a need to increase their production and productivity to ensure food and nutritional security in the country.

Among the grain legumes grown in the country, the kidney bean (*Phaseolus vulgaris* L.) is the most important winter legume crop, popularly known as rajma in Nepal. The majority of the vegetarian population treats legumes, especially kidney beans, as an important economical source of supplementary proteins, and is more common in the different cultural and festive programs of the country. Kidney bean is especially grown for dry seeds, but sometimes their green pods are used for fresh consumption. Not much net data on the area and production of kidney beans are available in the country, but based on the MoALD (2023), the beans are grown in 33,832 ha of land that produced 40,260 t with the productivity of 1. 2 t/ha. The kidney bean is generally grown in the Terai and Hilly regions of Nepal as a winter crop. Due to its good market demand and value, it is gaining popularity in High Hills, where it is grown in the summer season. The importation of dry kidney bean in a country is about 4080 t with the import value of 480 million NRs (DoC, 2023.). Though, there is an increasing trend in the area of beans however, its productivity is very low and has been stagnant over the 20 years (Pokhrel *et al.*, 2018).

There are various factors for the low production and productivity of kidney bean in the country, among them the inappropriate selection of the variety and unavailability of diversified high-yielding varieties (Pokhrel & Poudel, 2023, Meena *et al.*, 2017; Kalita *et al.*, 2016), inappropriate sowing time (Basnet *et al.*, 2022; Pokhrel & Dangi, 2022) and planting spacing (Kalita *et al.*, 2016; Pokhrel & Dangi, 2022) are the most common factors that influence on kidney bean production. In Nepal, only one variety of kidney bean has been released for general cultivation. The Grain Legumes Research Program (GLRP), Nepal has released only one variety of kidney bean and needs more varieties to be released to increase its production and productivity.

Therefore, it is important to study the performance of different kidney bean genotypes under Observation Nursery (OBN), Coordinated Varietal Trial (CVT) and Participatory Varietal Selection (PVS) for selecting suitable, high-yielding, and farmers’ preference varieties to release for general cultivation in the country.

**MATERIALS AND METHODS**

The series of experiments, *i.e.*, OBN, CVT and PVS were conducted at the Grain Legumes Research Program (GLRP), Khajura, Banke located at 28° 06'' 45' N latitude, 81° 35'' 58' E longitude and 182 masl during the winter season of two consecutive years of 2022/23 (Year I) and 2023/24 (Year II). The OBN included 24 genotypes of kidney bean, whereas CVT and PVS included 12 and 5 genotypes, respectively. The OBN and PVS were laid out in non-replicated, while CVT was conducted under Randomized Complete Block Design (RCBD). The released variety PDR-14 was used as the check variety in all the experiments. The size of an individual plot of OBN, CVT and PVS were 4.5, 6 and 12 m2, respectively, where the tested genotype was planted in 50 cm wider row spacing. Fertilizers were applied @ 5 t FYM and 120:60:40 kg N:P2O5:K2O per ha, and the remaining cultural practices like weeding and irrigation were adopted as needed.

**Soil Characteristics**

The composite soil sample of all the experiments were analyzed, where the soil of the experimental plots was found to be sandy loam with a neutral pH (6.4) that contains a low amount of organic matter (1.63%) and nitrogen (0.05%) but a high level of phosphorous (131.8 kg/ha) and potassium (272.4 kg/ha).

**Climatic Conditions of the Study Time**

During the experimental time from October to April, the study area received 80.1mm (2022/23) and 2.2 mm (2023/24) rainfall, where December, January and February are the coolest months in both years. The climatic conditions of the study time are presented in Table 1.

**Table 1. The average temperatures and rainfall during the study time**

|  |  |  |
| --- | --- | --- |
| Month  | 2022/23 | 2023/24 |
| Min Tem (ºC)  | Max Tem (ºC)  | Rainfall (mm)  | Min Tem (ºC)  | Max Tem (ºC)  | Rainfall (mm)  |
| October  | 19.92 | 30.33 | 486.51 | 20.2 | 32.66 | 1.16 |
| November  | 14.39 | 28.5 | 0 | 14.8 | 28.2 | 0.048 |
| December  | 9.4 | 24.13 | 0 | 10.23 | 24.32 | 0.208 |
| January  | 8.59 | 19.73 | 2.03 | 8.41 | 16.69 | 0 |
| February  | 11.4 | 19.73 | 0 | 8.406 | 23.34 | 0.258 |
| March  | 14.27 | 30.82 | 42.14 | 13.93 | 30.45 | 0.56 |
| April  | 16.89 | 35.25 | 35.93 | 17.73 | 47.85 | 0 |

**Statistical Analysis**

The data on yield and yield attributes parameters were analyzed statistically at a probability level of ≤ 0.05 in RStudio.

**RESULTS AND DISCUSSION**

**Observation Nursery (OBN)**

A total of 24 Rajma genotypes were evaluated across two consecutive growing seasons of 2022/23 and 2023/24 to assess their agronomic performance under varying climatic conditions. The genotypes exhibited considerable variation in key traits, including days to 50% flowering (ranging from 34 to 52 days), days to maturity (101 to 117 days), plant height (35 to 104 cm), number of pods per plant (12 to 49), number of seeds per pod (3 to 6), hundred seed weight (16 to 62 g), pod length (8-16 cm) and seed yield (ranging from 556 to 3942 kg/ha). Among the genotypes, PDR-14 recorded the highest combined yield (3360 kg/ha), followed by COLL#3 (2418 kg/ha), Ramechhap#2 (2315 kg/ha) and COLL#12 (2110 kg/ha), indicating their potential for high productivity. The mean seed yield of the kidney bean was found at 1579 kg/ha. Similar observations were also made by GLRP (2022) and GLRP (2023). The variation in traits like flowering and maturity days, plant height, pods per plant, seeds per pod, and seed weight might be due to differences in genetic characters and their potential. Similarly, the mean yield of the first year (1767 kg/ha) was higher compared to the second year (1427 kg/ha), which might be due to the growing environment of the first year was more favorable in terms of rainfall distribution as compared to the second year (Table 1).

**Table 2. Growth, development and yield of rajma under OBN at GLRP, Khajura (combined data of two years)**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SN | Genotypes | DTF | DTM | PH | PPP | SPP | HSW | PL | Seed Yield |
| Year I | Year II | Combined |
| 1 | COLL#3 | 47 | 114 | 103 | 30 | 6 | 23.5 | 10 | 2058 | 2778 | 2418 |
| 2 | COLL#4 | 34 | 115 | 76 | 21 | 3 | 44.5 | 8 | 1108 | 1111 | 1110 |
| 3 | COLL#10 | 47 | 114 | 72 | 17 | 5 | 21.5 | 11 | 925 | 2500 | 1713 |
| 4 | COLL#18 | 47 | 108 | 69 | 13 | 6 | 22.5 | 9 | 1150 | 1983 | 1567 |
| 5 | COLL#19 | 42 | 108 | 91 | 12 | 4 | 23.5 | 10 | 1517 | 1606 | 1562 |
| 6 | COLL#20 | 35 | 105 | 49 | 22 | 4 | 32.0 | 13 | 2092 | 1667 | 1880 |
| 7 | COLL#22 | 35 | 106 | 45 | 16 | 6 | 34.0 | 16 | 1608 | 1389 | 1499 |
| 8 | COLL#16 | 35 | 115 | 50 | 25 | 4 | 46.5 | 9 | 2192 | 1667 | 1930 |
| 9 | KBL-3 | 40 | 101 | 68 | 22 | 5 | 32.0 | 10 | 2117 | 1667 | 1892 |
| 10 | COLL#12 | 44 | 116 | 70 | 15 | 4 | 44.5 | 10 | 2275 | 1944 | 2110 |
| 11 | COLL#17 | 40 | 114 | 35 | 20 | 5 | 19.0 | 11 | 1333 | 1828 | 1581 |
| 12 | COLL#21 | 38 | 111 | 44 | 18 | 3 | 50.5 | 13 | 2367 | 1667 | 2017 |
| 13 | COLL#1 | 36 | 111 | 44 | 20 | 4 | 25.5 | 9 | 1000 | 1678 | 1339 |
| 14 | COLL#11 | 39 | 110 | 38 | 17 | 5 | 32.0 | 14 | 1417 | 1111 | 1264 |
| 15 | COLL#14 | 43 | 114 | 100 | 31 | 5 | 34.5 | 11 | 2600 | 1389 | 1995 |
| 16 | JURELI | 51 | 115 | 104 | 14 | 4 | 50.0 | 10 | 508 | 1111 | 810 |
| 17 | Baldhangre#1 | 43 | 116 | 88 | 21 | 4 | 62.0 | 11 | 1625 | 1011 | 1318 |
| 18 | Bajura#1 | 52 | 117 | 65 | 25 | 6 | 16.0 | 9 | 1550 | 1944 | 1747 |
| 19 | Bajura#2 | 47 | 115 | 70 | 21 | 5 | 20.0 | 8 | 1025 | 558 | 792 |
| 20 | Bajura#3 | 46 | 114 | 77 | 20 | 4 | 38.5 | 12 | 2033 | 1523 | 1778 |
| 21 | Bajura#4 | 43 | 115 | 62 | 49 | 5 | 22.5 | 9 | 1475 | 556 | 1016 |
| 22 | Bajura#5 | 41 | 110 | 84 | 29 | 5 | 20.5 | 8 | 1817 | 1389 | 1603 |
| 23 | Ramechhap#2 | 38 | 106 | 37 | 29 | 3 | 46.0 | 12 | 2958 | 1671 | 2315 |
| 24 | PDR -14 | 39 | 112 | 50 | 25 | 4 | 42.5 | 10 | 3942 | 2778 | 3360 |
|   | Mean | 42 | 111 | 66 | 22 | 4 | 33.5 | 11 | 1767 | 1427 | 1597 |
|   | Max | 52 | 117 | 104 | 49 | 6 | 62.0 | 16 | 3942 | 2778 | 3360 |
|   | Min | 34 | 101 | 35 | 12 | 3 | 16.0 | 8 | 508 | 556 | 791 |
|   | SD | 5.1 | 4.1 | 21 | 7.8 | 0.9 | 12.5 | 2.0 | 761 | 662 | 540 |

Note: DTF-days to flowering, DTM-days to maturity, PH-plant height in cm, PPP-pods per plant, SPP-seeds per pod, HSW-hundred seeds weight in grams, PL-pod length in cm.

**Coordinated Varietal Trial (CVT)**

The analysis of variance revealed significant genotypic differences for all the recorded traits, including days to 50% flowering, days to maturity, plant height, number of pods per plant, seeds per pod, hundred-seed weight, pod length, and seed yield in both years. Among the genotypes, Chitra was the earliest maturing (98 days) while the late-maturing genotypes were Panta-1, COLL#13, and COLL#6 (115 days). The tallest genotype was Panta-1 (103 cm), while the shortest was COLL#7 (39 cm). The highest number of pods per plant was recorded in COLL#7 (24 pods), and the lowest in Panta-2 (14 pods). The bold hundred seed weight was observed in Pant-1 (48.5 g). Pod length varied from 8 cm in COLL#6 to 16 cm in Panta-2. Regarding combined seed yield, Chitra recorded the highest combined yield (2399 kg/ha), followed by PDR-14 (2193 kg/ha), Panta-2 (1988 kg/ha), BL-63 (1962 kg/ha), and Panta-1 (1828 kg/ha).

These findings align with those reported by Kumar *et al.* (2020), who emphasized the importance of selecting early maturing and high-yielding genotypes for sustainable production in pulse-based cropping systems. Similarly, Thakur *et al.* (2019) noted that pod number and seed weight were the major determinants of yield potential in common beans, and genotypes exhibiting stability across seasons should be prioritized in varietal release pipelines. Therefore, the identified high-performing lines such as Chitra, PDR-14, Panta-2, BL-63, and Panta-1 could be valuable genetic resources for future breeding programs aimed at enhancing the productivity and adaptability of kidney bean. Likewise, the mean yield of the first year (2013 kg/ha) was higher compared to the second year (1578 kg/ha), because of first year was more favorable in terms of rainfall distribution as compared to the second year (Table 1).

**Table 3. Performance of rajma genotypes in coordinated varietal trial at GLRP, Khajura, Banke (combined data of two years)**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SN | Genotypes | DTF | DTM | PH | PPP | SPP | HSW | PL | Seed Yield |
| Year I | Year II | Combined |
| 1 | BL-63 | 42 | 103 | 41 | 16 | 4 | 36.5 | 10 | 2547 | 1376 | 1962 |
| 2 | Kanpur | 41 | 112 | 53 | 18 | 5 | 48.0 | 13 | 1772 | 1019 | 1396 |
| 3 | Chitra | 40 | 98 | 46 | 19 | 5 | 36.5 | 11 | 2762 | 2037 | 2399 |
| 4 | Panta-1 | 43 | 115 | 103 | 21 | 5 | 48.5 | 10 | 2175 | 1481 | 1828 |
| 5 | Panta-2 | 40 | 106 | 53 | 14 | 6 | 32.5 | 16 | 2169 | 1806 | 1988 |
| 6 | NL-1 | 40 | 98.5 | 45 | 21 | 5 | 37.0 | 11 | 1772 | 1713 | 1743 |
| 7 | COLL#7 | 45 | 109 | 39 | 24 | 6 | 19.5 | 11 | 1618 | 1725 | 1672 |
| 8 | COLL#13 | 45 | 115 | 86 | 20 | 6 | 26.5 | 11 | 1662 | 1759 | 1711 |
| 9 | COLL#6 | 47 | 115 | 87 | 21 | 4 | 18.0 | 8 | 1382 | 1014 | 1197 |
| 10 | COLL#2 | 39 | 103 | 46 | 18 | 5 | 44.5 | 12 | 1845 | 1435 | 1640 |
| 11 | Coll#9 | 40 | 106 | 45 | 16 | 6 | 31.5 | 12 | 2010 | 1620 | 1815 |
| 12 | PDR-14  | 43 | 112 | 54 | 19 | 4 | 41.5 | 10 | 2442 | 1944 | 2193 |
|  | Mean | 42 | 108 | 58 | 19 | 5 | 35.0 | 11 | 2013 | 1578 | 1796 |
|  | F test | \*\* | \*\* | \*\* | \*\* | \*\* | \*\* | \*\* | \*\* | \*\* | \*\*  |
|  | LSD | 4 | 8 | 18 | 1.5 | 0.9 | 7.5 | 1.6 | 647 | 738 | 692 |
|  | CV | 8 | 1.85 | 17.5 | 17 | 10 | 12.0 | 7 | 15 | 28 | 21.5 |

Note: DTF-days to flowering, DTM-days to maturity, PH-plant height in cm, PPP-pods per plant, SPP-seeds per pod, HSW-hundred seeds weight in grams, PL-pod length in cm.

**Participatory Varietal Selection (PVS)**

The participatory varietal selection (PVS) trial at GLRP, Khajura, Banke (Table 4) showed the genetic variability among tested genotypes for key agronomic traits. Significant differences were observed in days to flowering (36–46 days), days to maturity (105–115 days), and plant height (44–96 cm), suggesting a wide maturity window and diverse growth habits. Genotype Arun-2 achieved the highest combined seed yield (3205 kg/ha), indicating its superior productivity and adaptability. Similarly, Utkarsh and Ambar also performed well, producing 3062 and 2802 kg/ha, respectively.

**Table 4. Performance of rajma genotypes in participatory varietal selection in Khajura, Banke (combined data of two years)**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SN | Genotypes | DTF | DTM | PH | PPP | SPP | HSW | PL | Seed Yield |
| Year I | Year II | Combined |
| 1 | Ambar | 41 | 115 | 47 | 18 | 4 | 41 | 8 | 1687 | 3917 | 2802 |
| 2 | Utkarsh | 46 | 114 | 90 | 14 | 6 | 41 | 11 | 2373 | 3750 | 3062 |
| 3 | Arun-2 | 42 | 110 | 96 | 18 | 5 | 42 | 14 | 2909 | 3500 | 3205 |
| 4 | Chitra | 36 | 105 | 44 | 15 | 5 | 36 | 10 | 2171 | 2250 | 2211 |
| 5 | PDR-14 | 42 | 112 | 50 | 17 | 4 | 45 | 10 | 1935 | 2917 | 2426 |
|  | Mean | 41 | 111 | 65 | 16 | 5 | 41 | 11 | 2215 | 3267 | 2741 |
|  | Min | 36 | 105 | 44 | 14 | 4 | 36 | 8 | 1687 | 2250 | 2211 |
|  | Max | 46 | 115 | 96 | 18 | 6 | 45 | 14 | 2909 | 3917 | 3205 |
|  | SD | 4 | 4 | 25 | 2 | 1 | 3 | 2 | 465 | 683 | 419 |

Note: DTF-days to flowering, DTM-days to maturity, PH-plant height in cm, PPP-pods per plant, SPP-seeds per pod, HSW-hundred seeds weight in grams, PL-pod length in cm.

**CONCLUSION**

The evaluation of rajma genotypes across different trials and agro-ecologies over two consecutive years revealed significant genotypic variation for important agronomic traits such as days to flowering and maturity, plant height, pods per plant, hundred seed weight, and seed yield. The observation nursery data identified the released and the check variety PDR-14 (3360 kg/ha) as a top seed yielder, and after this Ramechhap#2, COLL#3, and COLL#12 found better yielder than other tested genotypes. Similarly, in coordinated varietal trial, the genotype Chitra produced the 9% higher seed yield, shorter days to maturity, higher number of seeds per pod and pod length than the released and check variety PDR-14, making this genotypes suitable for shortening the winter season and climate change conditions. Likewise, the participatory varietal selection trial validated genotypes Arun-2, Utkarsh, and Ambar, as the higher seed yielders, with yield potential of 32, 26, and 15 % higher than the check variety PDR-14 (2426 kg/ha). Overall, these experiments concluded that the genotypes Ramechhap#2, COLL#3, and COLL#12 should be included in a coordinated varietal trial. Chitra, Panta-2, and BL-63 should be evaluated in a participatory varietal trial. Additionally, the genotypes Arun-2, Utkarsh, and Ambar should be released for general cultivation.

**Disclaimer (artificial intelligence)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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