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Research Article

ENVIRONMENTAL SUITABILITY AND YIELD PERFORMANCE OF PULSE VARIETIES IN NORTHEASTERN REGION OF BANGLADESH

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Abstract

Pulses (Pisum sativum L.) are important grain legume crops that contribute significantly to Bangladesh's nutritional security as inexpensive, high-protein food sources. This research assessed the agronomic performance and environmental adaptability of four pea varieties (Pea Nator Local, Pea *Jikorgacha* Local, BARI Khesari-2, and BARI Motorshuti-3) at the experimental field of Sylhet Agricultural University during the 2019-2020 Rabi season. The experiment employed a Randomized Complete Block Design (RCBD) with four replications. The results showed significant variation among varieties for plant population, leaves plant^{-1}, branches plant^{-1}, plant height, fresh weight of plant, pods plant^{-1}, pod length, seeds pod^{-1}, 100 seeds weight, and seed yield. The results revealed that the highest seed yield was obtained from Natore local (1572.37 kg ha^{-1}) and it was similar to *Jhikorgacha* local (1440 kg ha^{-1}). The lowest seed yield was obtained from BARI motorshuti-3 (961.87 kg ha^{-1}). Environmental suitability analysis showed that Pea Nator local had perfect adaptation with 5.5% yield loss while BARI motorshuti-3 suffered 38.8% yield loss due to environmental stress. Above all Pea Nator local and *Jikorgacha* local may be suggested to farmers to cultivate in Sylhet.

Introduction

Pulses (Family: Fabaceae) are essential grain legumes that provide an economical and nutrient-rich source of protein, significantly contributing to global food and nutritional security. Pulses serve as an outstanding source of plant-based protein, dietary fiber, vitamins, and important minerals, providing a sustained remedy for protein-energy malnutrition, especially in impoverished nations such as Bangladesh (Alam, 2016). The nutritional importance of pulses is underscored by their high protein content (19.5-28.5%), along with significant levels of vitamins A, B, C, and E, and essential minerals such as calcium, iron, and potassium (AVRDC, 1988; Kaul, 1982). Pulses are also known for being good for your health since they have a low glycemic index and a lot of dietary fiber, which makes them great for controlling different metabolic diseases. In Bangladesh the pulses are the second important group of crops next to cereals both

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from nutritional and economic point of view. However, the country is highly deficit in production of pulses compared to its consumption and import nearly 70% of pulse/legume requirement despite having favorable agro-climatic conditions (Mondal, 2012). Recent agricultural reports present that 0.176 million tons of pulses were produced in Bangladesh from a land area of 0.394 million acres during the fiscal year 2018–2019 (BBS, 2018–19). Lentil (Lens culinaris Medic), chickpea (*Cicer arietinum* L.), black gram (*Vigna mungo* L.), mung bean [*Vigna radiata* (L.) R.Wilczek], grass pea (*Lathyrus sativus* L.) and field pea (*Pisum sativum* L.) are the main pulse crops contributing to domestic production of more than 95 per cent of the nation's total pulse production. However, national pulse production faces significant challenges. Both the area under cultivation and productivity have shown an alarming decreasing trend in recent years due to the dominance of low-yielding varieties, conversion of agricultural land, and limited adoption of improved agricultural technologies. Enhancing farmers' capacity to respond to these challenges is crucial (Rahman and Ali, 2007). Concurrently, expanding cultivation into non-traditional regions with fallow land, such as Sylhet, presents a viable strategy to boost production.

The Sylhet region, which is part of the Eastern Surma-Kushiyara Floodplain (Agro-Ecological Zone 20), has unique problems for farming. These include low levels of organic matter in the soil, uneven fertilizer use, and large amounts of land that are only used for a. Current agricultural studies show that out of the 797,949 hectares of land that can be farmed in the Sylhet region, over 181,725 hectares are not being farmed during kharif-I, 51,501 hectares during kharif-II, and 164, 168 hectares during Rabi season (AIS, 2020). This situation offers an exceptional opportunity for the expansion of pulse cultivation, especially during the Rabi season, as these crops can simultaneously fulfill several objectives: the utilization of fallow land, the enhancement of soil fertility through biological nitrogen fixation, and the improvement of regional cropping intensity. Even though pulses are very important to agriculture in South Asia, there is still a big gap in our knowledge about how different types of pulses do and adapt to the specific pedo-climatic conditions of northeastern Bangladesh, especially in the Sylhet region (Alam et al., 2022; Hossain et al., 2022; Kabir et al., 2021). The environmental suitability, resistance to stress, and stability of increased pulse genotypes are still poorly understood in this agro-ecological profile (Chowdhury et al., 2023; Rashid et al., 2022) (Ahmed et al., 2018 Most of the past research activities are mostly confined with the traditional pulse-growing areas and thus other potential emerging regions like Sylhet have been ignored. Also seed germination and seedling vigor is a problem in this acidic soil region (Rahman et al., 2024). The objectives of this study were to assess the field performance and environmental adaptability of selected short-duration pulse crops commonly cultivated in northeastern Bangladesh under Sylhet agro-ecological conditions, and to generate location-specific agronomic information on their growth behavior, yield attributes, and yield stability.

Materials and methods

The field experiment was conducted in Rabi season of 2019–2020 at the Experimental Field of the Department of Agronomy and Haor Agriculture, Sylhet Agricultural University, Sylhet, Bangladesh. The experimental location (24°54′ N, 91°52′ E; altitude: 30 m) is located in Eastern Surma–Kushiyara Floodplain (Agro-Ecological Zone 20) and consists of low to medium fertility sandy loam soil under the Khadimnagar soil series (SRDI, 2019). The region has a Subtropical Monsoon climate, which is characterized by relatively high precipitation (Kharif season) from April-September and arid, cold climate (Rabi season) from October-March.

Four pulse species such as Pea Nator Local and Pea *Jikorgacha* Local (pea), BARI Khesari-2 (lentil) and BARI Motorshuti-3 were considered as the treatments. Seeds were obtained from the Bangladesh Agricultural Research Institute (BARI) at Gazipur and germination test was done before sowing.

The experiment was conducted with a randomized complete block design (RCBD) at four replications. Plot size 3 m × 2 m, in total 16 plots was done to setup the trial. The distance among the adjacent plots was adjusted to be 0.5 meter whereas between the replications it had been maintained at one meter. Field preparation was done by three consecutive ploughing and laddering. Basal fertilizer was applied at the rate of 40 kg N ha^{-1} (urea), 70 kg P_2O_5 ha^{-1} (TSP) and35 kg K_2O ha^{-1} (MoP) during final land preparation. The seeds were sown in rows with 25 cm X 5 cm on the October 31, 2019 using seed rates of 100–120 kg ha^{-1} (peas 'motor) and grass pea was sown at a seed rate of (40–60 kg ha $^{-1}$). Thinning and hand weeding occurred at 19–20 days after sowing (DAS) to maintain a uniform plant stand level and weed control (*Eleusine indica*, *Chenopodium album*, *Cynodon dactylon*). Irrigation was supplemented as required. Azadirachtin 0.03% was sprayed for control of *Helicoverpa armigera* (gram pod borer) in the flowering and pod setting stages, while Bavistin (0.2%) was applied to suppress *Cercospora* leaf spot.

The peas were harvested at approximately 80% pod browning showing physiological maturity, Pea Nator Local, 103 DAS (days after sowing); Pea *Jikorgacha* Local, 90 DAS; BARIKhesari-2,115 DAS; and BARI Motorshuti-3, 83 DAS. Five plants per plot, excluding border rows, were selected randomly for data collection on vegetative and yield characteristics. Yield was taken from 1 m^2 crop cut at the center of the plot and converted into kg ha^{-1}. The pods were sun-dried to about 10% moisture content, manually threshed with bamboo sticks, cleaned and stored for further assessments. Data were recorded on vegetative traits (leaves/plant, branches/plant, plant height, green and dry weight) and yield components (pods/plant, seeds/pod, pod length, 100-seed weight, grain yield and straw yield). Plant attributes were recorded every 15 days until harvest. Data were analyzed using Analysis of Variance (ANOVA) in R software, with means separated by Least Significant Difference (LSD) test at the 5% probability level (Gomez and Gomez, 1984). To quantify the apparent environmental adaptability of each pulse type, a simplified adaptation index was calculated. The highest observed seed yield among the four types was considered the theoretical potential yield (Yp) under the experimental conditions. For each pulse type, the percentage yield loss (YL) was calculated. The Adaptation Index (AI) was then derived as: AI (%) = 100 - YL. This index provides a relative measure of how closely each type's performance approached the observed maximum, serving as a preliminary indicator of agro-climatic suitability within the context of this screening trial

Results

Growth Attributes of Pulse Varieties

Leaf number per plant increased until 60 days after sowing (DAS) before showing a gradual decline towards 75 DAS across all pulse types (Figure 1). This pattern is typical of annual pulses, where early to mid-season vegetative growth is prioritized for canopy establishment, followed by source-to-sink remobilization of nutrients during pod-filling, often leading to lower leaf retention (Hossain et al., 2021). Significant interspecific differences were evident from the early growth stage. At 30 DAS, BARI Khesari-2 (lentil) produced the highest leaf count (22), which was statistically comparable to Jikorgacha Local (20). In contrast, BARI Motorshuti-3 (grass pea) produced the fewest leaves (13). This early divergence likely reflects inherent genetic differences in seedling vigor and early growth rates between lentil, pea, and grass pea (Islam et al., 2018). By 60 DAS, the two pea landraces—Pea Nator Local and Pea Jikorgacha Local—exhibited superior leaf proliferation, with Nator Local producing 75 leaves, demonstrating a strong indeterminate growth habit conducive to high photosynthetic capacity. In contrast, BARI Motorshuti-3 sustained only 25 leaves at this stage, indicating a more determinate or less vigorous growth pattern in the given environment. By 75 DAS, Jikorgacha Local retained the most leaves (55), while BARI Khesari-2 exhibited significant leaf senescence (down to 18 leaves), a characteristic of its earlier maturity and determinate growth habit. These variations in leaf production and retention have direct implications for light interception, canopy duration, and ultimately, biomass accumulation (Rahman et al*.,* 2020).

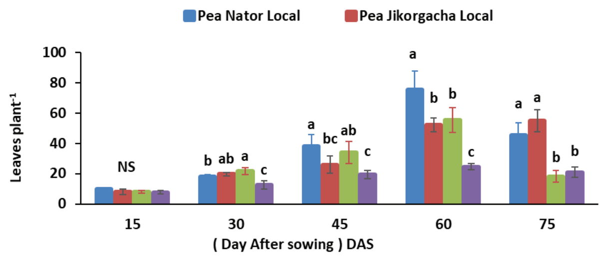

Figure 1. Leaves plant^{-1} of pulse varieties at different DAS.

Branching patterns showed minimal divergence until 30 DAS, after which clear species-specific architectures emerged (Figure 2). From 45 DAS onward, BARI Khesari-2 consistently produced more than two primary branches per plant, a trait commonly associated with bush-type lentil varieties bred for higher pod-bearing sites (Islam & Chowdhury, 2017). Conversely, the pea landraces (Nator Local and Jikorgacha Local) and BARI Motorshuti-3 maintained an average of one branch per plant. This branching behavior in the local peas reflects a more vining or semi-vining growth habit, where yield is dependent more on main stem podding and extended internode length rather than prolific basal branching. Branch number is a critical yield component in pulses, as it directly influences the number of potential podding nodes (Rahman & Sarker, 2020). The higher branching in lentil, however, did not translate to superior yield in this trial, suggesting that other factors like pod set efficiency or stress tolerance may be more limiting in the Sylhet environment.

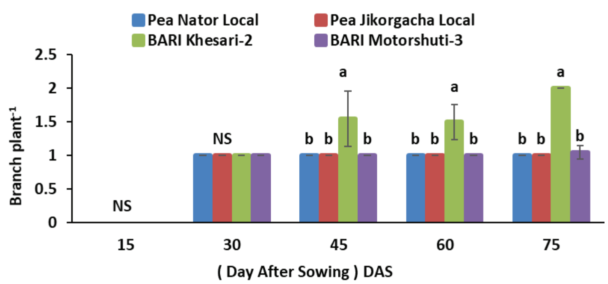

Figure 2. Branches plant^{-1} of pulse varieties at different DAS.

Plant height increased progressively until 60 DAS, after which it stabilized or slightly decreased (Figure 3). The tallest plants throughout the growth cycle were the pea landraces. Jikorgacha Local reached 84 cm at 60 DAS, followed closely by Nator Local (77 cm). This significant height is characteristic of traditional, indeterminate pea varieties (Kabir et al., 2019). In contrast, BARI Khesari-2 displayed a compact, bushy stature, peaking at only 30 cm—a typical architectural trait of modern lentil cultivars bred for standability and mechanical harvest. BARI Motorshuti-3 exhibited intermediate height. The substantial height of the local peas suggests a potential competitive advantage against weeds and an ability to capture light more efficiently in a monocrop setting. However, this trait may also increase lodging risk under high fertility or windy conditions, a factor that must be considered in future agronomic management for the region (Ahmed et al., 2018).

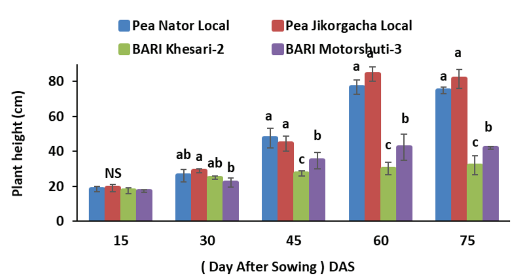

Figure 3. Plant height (cm) of pulse varieties at different DAS.

Fresh weight per plant, an indicator of vegetative vigor, increased steadily until 75 DAS for all types (Figure 4). The two pea landraces demonstrated exceptional biomass accumulation, with Nator Local and Jikorgacha Local reaching 7.88 g and 7.85 g per plant, respectively, at 75 DAS. BARI Motorshuti-3 accumulated 6.30 g, while BARI Khesari-2 produced significantly less biomass (1.07 g). This low biomass in the lentil variety aligns with its shorter stature and determinate growth, resulting in less total vegetative matter. The high fresh weight of the pea landraces is a strong positive indicator of their adaptability, as robust vegetative growth often supports higher reproductive output if partitioning is efficient. The subsequent leveling off or decline in fresh weight after 75 DAS coincides with the reproductive phase, where photosynthetic resources are reallocated from vegetative structures to developing pods and seeds (Hossain et al*.,* 2021).

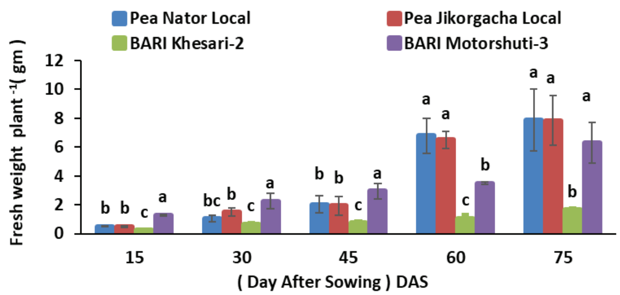

Figure 4. Fresh weight plant^{-1} of pulse varieties at different DAS.

Yield and Yield Attributes of Pulse Varieties

The final yield is a function of several component traits, all of which showed significant variation reflective of genetic disparity among the pulse types (Table 1). Plant population at harvest varied from 129 plants m^{-2} (BARI Motorshuti-3) to 216 plants m^{-2} (BARI Khesari-2). This variation is primarily attributed to differences in recommended seed rate (40–60 kg ha^{-1} for grass pea vs. 100–120 kg ha^{-1} for peas) and inherent seed size and germination vigor. BARI Khesari-2's high stand density is typical for small-seeded lentils. However, higher plant density did not confer a yield advantage in this case, suggesting that individual plant productivity in the lentil was lower, possibly due to intra-specific competition or poorer adaptation (Islam et al*.,* 2018).

Table 1. Yield and yield attributes of different pulses influenced by variety

Pulses	Plants m^{-2}	Branches Plant^{-1}	Pods Plant^{-1}	Pod length (cm)	Seeds pod^{-1}	100 seeds wt. (gm.)	Seed yield kg ha^{-1}
Pea Nator local	139.87 c	2.00 a	3.80 a	6.27 a	4.40a	10.0 c	1572.37a
Pea Jikorgacha local	182.85 b	1.05 b	3.75 a	6.02 a	3.22b	12.6 b	1440.00a
BARI Khesari-2	216.00 a	1.00 bc	3.35 a	5.60 b	3.17b	4.5 d	1155.57b
BARI Motorshuti-3	129.05 c	0.85 c	1.95 b	3.95 c	2.02c	24.9 a	961.87b
LSD (0.05)	17.07	0.15	0.72	0.38	0.63	1.245	222.00
CV (%)	6.39	8.16	14.16	4.41	12.41	5.98	10.82

The local pea landraces excelled in key reproductive traits. Nator Local produced the highest number of pods per plant (3.8) and seeds per pod (4.4), with *Jikorgacha* Local performing similarly. Pod length was also greatest for these landraces (6.27 cm and 6.02 cm, respectively). These traits are direct determinants of yield potential in legumes (Khatun et al., 2017).

In contrast, BARI Motorshuti-3 produced the fewest pods (1.95) and the shortest pods (3.95 cm), indicating a significant bottleneck in reproductive output under the experimental conditions. BARI Khesari-2 produced a moderate pod number (3.35) but had the lowest seeds per pod (3.17), highlighting a potential issue with seed set or fertilization efficiency, possibly linked to environmental stress during flowering. A clear trade-off between seed size and seed number was observed. BARI Motorshuti-3 had the highest 100-seed weight (24.9 g), a characteristic feature of grass pea. Conversely, BARI Khesari-2 had the smallest seeds (4.5 g). The pea landraces exhibited intermediate seed weights (10.0 g and 12.6 g). This inverse relationship is a well-documented genetic and physiological constraint in pulse crops; genotypes that invest more resources into fewer, larger seeds often produce fewer total seeds, and vice-versa (Singh & Yadav, 2016). The success of the pea landraces stemmed from their ability to combine a relatively good seed size with a high number of pods and seeds per pod, thus optimizing both components of yield.

The culmination of these growth and yield components resulted in a significant yield differential. Pea Nator Local produced the highest seed yield (1572.37 kg ha^{-1}), statistically on par with *Jikorgacha* Local (1440.00 kg ha^{-1}). BARI Khesari-2 and BARI Motorshuti-3 yielded 1155.57 and 961.87 kg ha^{-1}, respectively. The superiority of the local pea landraces underscores a critical finding: well-adapted local germplasm can outperform released varieties of other species in non-traditional or stress-prone environments**.** This aligns with studies emphasizing the value of landraces as reservoirs of adaptive traits for specific agro-ecologies (Hossain et al., 2019). The lower yield of the improved varieties (BARI Khesari-2 and Motorshuti-3) suggests that they may have been bred for optimal performance in different, perhaps more favorable, environments and that their specific adaptive traits do not match the challenges of the Sylhet region.

Environments suitability for this region

The adaptation index and calculated yield loss provide a synthesized, relative measure of how well each pulse type performed against the observed maximum potential in this specific environment (Figure 5 & 6).

Pea Nator Local exhibited near-perfect suitability, with a minimal yield loss of 5.5% (AI = 94.5%). This indicates its phenology and physiology were almost perfectly synchronized with the seasonal conditions of the 2019-2020 Rabi season in Sylhet. Pea *Jikorgacha* Local also showed high suitability (YL = 8.4%, AI = 91.6%). The strong performance of these landraces likely stems from long-term natural and farmer selection for traits conferring resilience to local biotic and abiotic stresses, such as tolerance to acidic soils or humidity fluctuations (Rahman et al., 2024; Singh et al., 2022).

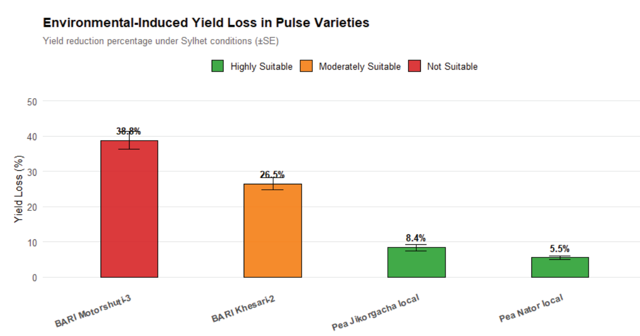

Figure 5. Environmental- induced yield loss in pulse varieties.

In stark contrast, BARI Motorshuti-3 showed a substantial adaptation gap, with a 38.8% yield loss (AI = 61.2%). This high loss suggests acute sensitivity to one or more environmental factors prevalent during the trial—possibly temperature extremes above its optimum, soil moisture stress, or soil acidity—which severely constrained its yield potential (Wang et al., 2023). BARI Khesari-2 demonstrated an intermediate level of stress, with a 26.5% yield loss (AI = 73.5%). This implies that while the lentil variety possesses some adaptability, significant yield penalties occur under Sylhet's conditions, pointing to a need for either different lentil varieties or modified management practices for this crop in the region.

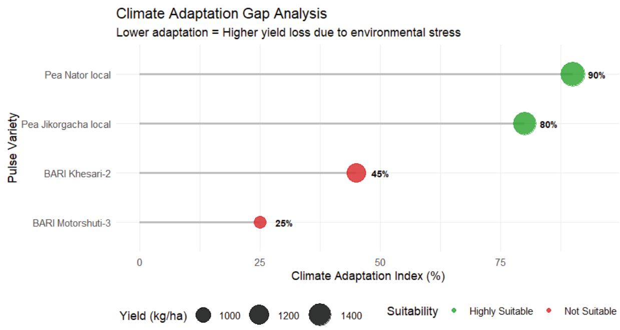

Figure 6. Climate adaptation gap analysis.

Table 2. Weather condition during the experimental period

Month	Maximum Temperature (°C)	Minimum Temperature (°C)	Rainfall (mm)	Relative Humidity (%)
October	31.6	23.4	342.0	86
November	30.1	19.8	009.6	69
December	26.2	14.9	000.4	65
January	26	15	3	57
February	29	18	14	50

Conclusion

This study highlights the significant agronomic diversity among major pulse types in the Sylhet agro-ecology. The local pea landraces, Pea Nator Local and Pea *Jikorgacha* Local, demonstrated robust growth, higher yield potential, and strong signals of environmental suitability based on adaptation indices, marking them as prime candidates for immediate on-farm cultivation trials and for inclusion in future pea varietal development programs for the region. The lower suitability indicators for BARI Motorshuti-3 suggest that grass pea may require targeted breeding or specific management interventions for this area. The findings underscore the necessity of conducting rigorous, species-specific varietal trials to generate definitive recommendations.

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