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A COMPREHENSIVE REVIEW ON PHENOTYPIC AND AGRONOMIC CHARACTERIZATION OF FIELD PEA (*PISUM SATIVUM* L.) IN INDIA

Mudit Pandey, Sachchida Nand Mishra*, Udit Pandey, Ansar Ahmad, Jay Prakash and Rahul Kumar Patel

Faculty of Agriculture, Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj, U.P., India
*Corresponding author E-mail: sonmishra2@gmail.com
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ABSTRACT

Field pea (*Pisum sativum* L.) is an important cool-season legume crop in India, playing a major role in sustainable agriculture, soil fertility through nitrogen fixation, and dietary protein supply. Field pea have economic and ecological importance, but the crop underutilized in terms of systematic breeding and research. This review gives a detailed overview of the phenotypic and agronomic characterization of field pea genotypes in India, emphasizes the variability in morphological characters such as plant architecture, leaves types, growth habits, flower colour, seed characteristics–seed size, seed cotyledon colour, seed coat colour. Agronomic characters like yield, disease and insect resistance, adaptability to many agro-climatic zones is seriously evaluated. The review highlights the role of field pea by morphological and agronomic traits expression and standardized the protocol for accurate selection in breeding programs. Also, the review defines potential methods to bridge the gaps through modern phenotyping methods. By analysing present knowledge and identifying key research gaps, this review objectives to support future breeding efforts for the genetic improvement and sustainable cultivation of field pea in India.

Keywords **:** Phenotypic character, Agronomic character, Genotypes Environmental conditions, Field Peas.

Introduction

Pea (*Pisum sativum* L.) are among oldest legume crop ever domesticated and grown by the humans. Over the time, breeders have been carefully selected and bred for desirable characters that develop them better for farming, eating, and many other purposes. There are many subspecies of P. sativum, each with distinct characters and found in different part of the world (Abdel *et al*., 2021).

The winter legume plant Pisum sativum L. is a member of the Fabaceae family. Its protein-rich seeds are the main reason it is grown in more than 95 countries for food and feed. Gondalia *et al*. (2022). Peas have a strong nutritional profile, making them a valuable food option for helping to feed the over 900 million people around the world who are undernourished (Devi *et al*., 2024). In 2022, green peas were grown on about 2.61 million hectares globally, producing nearly 21 million tonnes. China and India lead the way, harvesting around 11.5 million and 6.18 million tonnes of fresh peas respectively, making them the top two producers in the world (FAO, 2022).

The farmers face biggest challenges is to decide which pea variety to grow. The choice usually depends on characters that are suitable for their farming needs, how the pea crop will be used and they offer environmental benefits. The peoples consume directly a third part of the daily requirement protein from legumes. The global population are continued to growing and there should be focus to solve healthy eating issues like food shortage and protein or nutrients deficiency, the legumes demand is continued to rising. The pea crop is high value protein rich crop and it is used for food or non food both applications. This trait of the crop is attracted growing interest, it is an

important part of our diets and important source of vegetables or pulses (Santalla *et al.*, 2001).

These global challenges provide attention to the importance of developing improve and high yielding pea crop varieties that can enhance the overall crop production, over coming the global challenges. But developing new diseases resistant and high production crop varieties required to access various types of germplasm, plants that carry important traits breeders need to develop enhanced crop varieties. This crop is one of the oldest cultivated food crops, that have been grown from centuries and farmers choosing plants with desirable characters. Over the time, during this evolutionary and selective process various wild and distant varieties of pea has been lost, show reduction in the crop genetic variability (Rana *et al*., 2010).

Genetic diversity is known as the full range of different allele combinations found within a species' gene pool. The genetic makeup is more diverse, the characters of a variety in a species are broader. This crop diversity is valuable, playing an important role for supporting global food security and protecting the environment. This genetic variation of a crop develops good understanding to breeders and researchers develop better planning for future crop improvement. For this reason, genetic diversity is an important part of crop improvement (Rana *et al*., 2017).

Characteristics

Pea varieties are come from a wide range of traits, including different cotyledon colour, plant structure, sowing time, winter hardiness, seed features, and flowering duration. Evaluating genetic diversity is essential for conservation in the food and feed sectors.

Peas are an annual legume that is sown in winter or early spring and bloom in chilly climate. The ideal temperature range for growing peas is between 55 and 65°F. Peas are resistant to frost because hypogeal germination is found in pea. Pea is a self-pollinated crop. Peas typically thrive earlier and mature slowly in cool climate with enough rainfall, but they grow swiftly in regions that are experiencing drought or other stresses. Growth stages, known as seed development, flowering, sprouting, flowering duration, and other growing phases, that are differ greatly based on the surroundings (Mohan *et al*., 2013).

Pea growth is affected by climate, temperature, soil quality, diseases, insects and competition from weeds and other plants. Some special types of peas are adapted to few environments, while others are versatile and can grow in a various condition. The understanding of which characteristics work best in which area can help in the successful crop cultivation.

The physical characteristics of peas can vary depending on both the environment and the genetics of plant varieties. Traits such as flower colour, cotyledon colour, seed coat colour and pattern, and texture of the seed surface are important not just for human consumption and animal feed, but also when choosing peas as a winter cover crop. Some key traits are discussed below to choose right type of pea for your farm (Devi *et al.*, 2025).

Kind of leaves: - The type of leaves a pea plant has can give insight into how well it can handle tough growing conditions (Endale *et al*., 2019; Mikić *et al.*, 2011).

- **Normal leaves: -** Pea plants having normal leaves usually have 1–3 pairs of small leaflets, with a branched tendrils at the tip of the plant and leafy structures called stipules. These Pea plants tend to grow that are about 4 – 6 feet in length.
- These types of pea plants produce extra biomass and higher yields, which helps to compete better against weeds.
- They are suitable for use as forage, particularly when grown alongside cereal grains.

Fig. 1 : 'Kashi Nandini' variety of pea with normal leaves. Photo taken at the PRSU, Naini, Prayagraj, Research farm.

1. **Semi-leafless: -** pea plants have leaflets that are mostly turned into tendrils, but they still have regular stipules. Their vines usually grow about 2 to 4 feet long.

- Although they have fewer leaves, they stand up better and are less likely to fall over.
- They're ideal for mechanical harvesting, especially when growing peas for grain.
- These pea plants are also less affected by fungal diseases.
- They don't cover the ground as well; you'll need to plant more densely to compete better against weeds.
- These pea plants are best for dry pea or grain production.

Fig. 2 : 'Swami Aparna' variety of pea with semi leafless. Photo taken at the PRSU, Naini, Prayagraj, Research farm.

2. **Leafless: -** pea plants have their leaflets completely turned into tendrils.

- They are typically to produce small seeds, which helps slow down the plants growth.
- These plants don't usually grow side branches, and if they do, those branches don't add much to the yield when planted closely together.
- They tend to flower earlier than other types.

Growth Habit

Pea plants growth habit is affected by its genetic makeup and the environment around it. All environmental factors, the availability of water during the growing season of pea plays important role in limiting how peas grow well. Other things such as how much space they have, the nutrients in the soil, and access to sunlight also affect their growth (Tekin and Bicer, 2023; Mikić *et al*., 2011).

- **Tall Vine Length – Indeterminate Type** These pea plants are a better for the regions that deal with heat and drought stress, especially during their reproductive phase.

Fig. 3 : 'Pant matar - 155' variety of pea with tall vine length. Photo taken at the PRSU, Naini, Prayagraj, Research farm.

- These pea plants are continued to thrive all summer long, as long as temperatures and moisture levels are favourable.
- The plants grow long vines and form a thick canopy, which means they produce more overall plant material (biomass).
- The growing tip (terminal bud) keeps growing and stays in a vegetative state as long as the conditions are right—even when flowers are starting to develop.
- They're a bit tougher to harvest since they tend to fall over more easily (lodging).
- These types are usually more resistant to winter conditions and are often planted in late summer, early fall, or even late fall.

Short Vine Length – Determinate Type

- These pea plants are grown fast and mature earlier, making ideal for spring season planting.
- Pea plants having an upright growth habit, which makes them easier to manage.
- These are suitable for grain production.
- Recommended for the regions of short growing seasons, cool summers, and longer rainfall.
- They have a set flowering period, rather than blooming continuously.

Fig. 4 : 'M - 7' variety of pea with short vine length. Photo taken at the PRSU, Prayagraj, research farm.

Branching Patterns (Indeterminate or Determinate) – These can differ from one cultivar to another and are often shaped by the environment.

For example, Austrian winter peas, known for their strong winter-hardiness, tend to grow multiple spreading branches that lie close to the ground during fall and winter.

Before they even begin to flower, they build up a lot of green growth (biomass), making them excellent choices for green manure, cover cropping, or forage.

Flower Colour

Flower colour in peas was one of the earliest traits studied in genetics. It's closely tied to anthocyanin content a lack of this pigment not only changes the colour but also makes the seeds taste milder and more appealing (Tedin, 1920).

- **Purple Flowers** – Usually paired with reddish-purple colouring in the leaf axils and purple specks on the seed coat. Found in Austrian winter peas or Maple peas. These tend to be less tasty.

Fig. 5&6 : 'Rachna' variety of pea with purple colour flower. Photo taken at the PRSU, Prayagraj, research farm.

- **Pink Flowers** – These plants show reddish colouring in the leaf axils and light red specks on the seeds.
- **White Flowers** – Characterized by a clear seed coat and no colouring in the leaf axils. These peas haven't anthocyanin's, giving a natural sweet flavour. Most of the grain and vegetable pea varieties comes into this category.

Fig. 7&8 : 'IPFD 9-2' variety of pea with white colour flower. Photo taken at the PRSU, Naini, Prayagraj, Research farm.

- **Seed Characteristics**

These characteristics can vary depending on the type of chosen cultivar, and they play an important role in how the crop is valuable, when grown for sale (Santos *et al*., 2019).

Shape and Surface Texture

- Smooth and round seeds are most commonly used for dry edible peas (also called grain peas). Their shape makes it easier to remove the seed coat. These peas usually have a higher starch content and tend to be less sweet.
- Angular, wrinkled, or dimpled seeds are mainly used as a source of protein and energy for livestock. They can be more sensitive to high temperatures but are better at absorbing water. These types generally have lower starch levels and are also used in various food products for people.

Fig. 9 : Different shapes and surface texture of pea seeds. PRSU, Prayagraj.

Seed Cotyledon Colour

The colour of the seed's cotyledon (the inner part of the seed) is an important factor, especially for peas meant for the edible market, though it also matters in food and animal feed products. (Santos *et al.*, 2019)

- Yellow cotyledons are not used in fresh vegetable products. The seeds mature, they are losing their green colour and turn yellow but if they are not fully mature, they have stay green.
- Green cotyledons are used in human food markets, when the colour is rich and vibrant. However,

expose to sunlight can bleach green peas, making them look yellow. In general, green pea varieties don't yield as much and may be less tolerant to powdery mildew and have weaker stand ability compared to yellow types but there are definitely some exceptions that perform well.

Fig. 10 : Different cotyledon colour of pea seeds. PRSU, Prayagraj.

Seed Coat Colour

- The seed coat colour reflects differences in tannin content, which is an important characteristic for the edible pea market.
- The coloured seed coat such as brown, grey, purple, or green— often which provide natural protection for seeds against few root rot diseases.
- The seed coat is usually found in white flower pea like clear, white or colourless and they have lower level of tannin.

Seed Coat Pattern

- The pattern on the seed coat also plays a role in how the peas are used, especially in deciding whether they're suitable for human consumption or better suited for animal feed.
- Blotched patterns are found in peas with coloured flowers. For example, seed coat is grey generally not accepted in human food markets and used as animal feed or considered lower-quality grain.
- Seeds without mottling are desirable for food markets, that focused on human consumption.
- Violet or black eye patterns can occur in peas with either coloured or white flowers like in black-eyed peas.
- Mapping patterns are typically linked to wild varieties and peas with coloured flowers.

Seed Size

Seed size is greatly determined by market demands and can vary between different pea cultivars and same cultivar. It is an important factor when planning how much seed are plant. The seed size affects the seed rate and overall planting density, farmers should always check the number of seeds per unit for each batch before planting to make sure they're getting the spacing just right.

Agronomic traits

It is an important to follow good farming practices that match the cultivar being grown which help to achieve best results from a crop. That includes choose the right location according to the field history, used high-quality seeds, and maintaining the crop properly after planting. The uses of the crop in mind for like food, feed or another purpose that can greatly affect its overall value. (Dhall *et al*., 2023)

Sowing time: sowing of pea crop in India on the following dates: (Kaur *et al.,* 2024)

- 15^{th} Oct to 15^{th} Nov

Yield

The crop yield is vary depending on environmental factors, including both biotic and abiotic factor, such as the sowing date for different pea varieties. For winter pea, sowing in late summer that help boost yield and protect the crop from frost. The winter and spring pea are sensitive to drought and heat stress during flowering, that can significantly reduce seed production (Baite *et al.,* 2023).

Soil

The well-drained soil is suitable for pea cultivation and standing water or waterlogged condition affect the crop. They can survive heavy clay soil but that are not ideal for getting the best growth and yield (Mohan *et al.,* 2013).

- The seed can germinate when the temperature of the soil reaches around 40℉ and seedling emerging within 10 -14 days.
- In early stages good germination requires adequate soil moisture.
- The pea plants have a low tolerance for salty or saline soil condition.

Diseases and Insects

Pea crop is a good break crop in rotation system, helping to reduce disease and insect pressure in the field and also enhancing soil fertility. However, they are sensitive to several major diseases and insects. According to (Biddle 2007), some of the most common issues affecting pea crop including:

- Ascochyta blight
- Powdery mildew and downy mildew
- Fusarium wilt in most pea-producing regions across the world, *Fusarium oxysporum* f. sp. pisi (Fop) causes the damaging disease known as fusarium wilt of peas, which can result in yield losses of 30 to 100%. Deng *et al.* (2024).
- Viral diseases in pea crop such as common mosaic and pea seed-borne mosaic.

Nitrogen Fixation

Pea crop are found a strong taproot, but their smaller roots stay in the upper layers of the soil. (Dhillon *et al.*, 2022). These pea crop root make a great partnership with beneficial soil bacteria, making nodules that help plant to take nitrogen from the air and store in the roots. This process are known as nitrogen fixation and it is important process for healthy crop growth.

To support this process, pea seeds should be properly treated with Rhizobium leguminosarum and applied directly to the seed or into the soil. Nodules are usually start forming about 2 weeks after the plants growing. If they not form, the pea plant may turn light green or yellow and growth are stunted. As legumes that fix nitrogen from the atmosphere, peas are essential for sustaining healthy soil and low-input farming systems. When cultivated as an annual crop, they can produce grains and vegetables with less fertilizer. Sharma *et al.* (2025).

Check the nitrogen fixation is working or not, dig out few pea plants and check the root nodules. Various factors are affecting the nitrogen fixation process, like herbicide use, poor drainage system, unfavourable soil conditions like low or high pH and different types of soil.

Field pea breeding programs must be run effectively in order to boost this crop's output.

In order to generate high-yielding cultivars, genetic diversity is a necessary prerequisite for crop development programs. Conversely, some yield contributing qualities are linked to yield, which is a complex character. Developing an effective breeding program requires a thorough understanding of character association.

Conclusion

The assessment of phenotypic and agronomic characterization of many diverse field pea (*Pisum sativum* L.) genotypes in India enhance the important potential for improving field pea productivity through targeted breeding. The observation of phenotypic and agronomic characters such as leaves types, growth habits, flower colour, seed characteristics – seed size, seed cotyledon colour, seed coat colour, seed yield shows the richness of genetic resources available in this agro-climatic zone. This study highlights the superior genotypes with desirable trait combinations as promising candidates for further breeding programs aimed at yield stability and adaptability. Overall, the study provides a vital resource for plant breeders, geneticists, agronomists and helping the development of high-yielding, climate-resilient field pea cultivars customized to the specific ecological conditions of the Indian subcontinent, particularly in eastern Uttar Pradesh.

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Conflicts of Interest Statement

We have no conflicts of interest to disclose. Authors declare that they have no conflicts of interest. The research was fully done in independently not any financial support involved.

Author contribution Contributed to the conception and design of the analysis paper Contributed to the data collection Data and analysis tools wrote the analysed paper. Also evaluated the paper and then suggested to publish in this journal

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