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REVIEW ARTICLE

ORIGIN, DOMESTICATION, TAXONOMY, BOTANICAL DESCRIPTION, GENETICS AND CYTOGENETICS, GENETC DIVERSITY AND BREEDING OF PEA (*Pisum sativum* L.)

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ABSTRACT

Pea (*Pisum sativum* L.) belongs to the Family Fabaceae, subfamily Faboideae , genus *Pisum* and species *Pisum sativum* L. Several varieties of *P. sativum* have been bred. Widely cultivated examples include: 1) *Pisum sativum* var. *macrocarpon* is commonly known as the Snow pea and 2) *Pisum sativum* var. *macrocarpon* ser. cv. is known as the sugar snap pea. There are three different types of peas, each suited to different ways of eating them - snap peas, snow peas, and shelling peas. *Pisum* is an ancient Latin name for the well-known pea. *Sativum* means "planted," or, more literally, "that which is sown". Common Names of pea are dry pea, Chinese pea, Chinese pea pod, Chinese snow pea, edible pod pea, podded pea, snow pea, sugar snap pea. As one of the most ancient crops in the world, pea played an important role in the introduction of agriculture in post-glacial Europe, often representing the main pulse in the diets of local communities across the continent. It is consumed as fresh vegetable or dry seed throughout the world. It is also one of the most popular vegetables grown for home use by home gardeners. Peas are cultivated both in agriculture (field peas) and horticulture (garden peas) and are used for both for fodder and food, either grown to full maturity or eaten as a fresh vegetable. Peas can be bought fresh, canned, or frozen, and dried peas are commonly used in soups. Some varieties, including sugar peas and snow peas, produce pods that are edible and are eaten raw or cooked like green beans; they are popular in East Asian cuisines. Domesticated about 11,000 years ago or so, peas are an important human and animal food crop cultivated throughout the world. *Pisum sativum* L; 2n=2x=14) also commonly known as English pea or green pea and is a commonly grown leguminous vegetable in the world. Pea is pollinated due to cleistogamous flower structure and has less than percent out crossing. The seeds are dispersed when the pod reaches maturity and bursts open. It scatters the peas over as wide a distance as it is possible for the plant. Field peas or "dry peas" are marketed as a dry, shelled product for either human or livestock food, unlike the garden pea, which is marketed as a fresh or canned vegetable. The major producing countries of field peas are Russia and China, followed by Canada, Europe, Australia and the United States. Major production states are UP, Bihar Haryana, Punjab, Himachal Pradesh, Orissa and Karnataka. It is worthwhile to mention that large scale production of vegetable peas for international market is still based largely on old varieties. Arkel introduced in India in 1970s still holds ground and is a household name in vegetable pea growers and consumers. In this review article on Origin, Domestication, Taxonomy, Botanical Description, Genetics and Cytogenetics, Genetic Diversity, Breeding, Uses, Nutritional Value and Health Benefits of pea are discussed.

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INTRODUCTION

Pea (*Pisum sativum* L.) belongs to the Family Fabaceae, subfamily Faboideae , genus *Pisum* and species *Pisum sativum* L. (Wikipedia, 2023). Several varieties of *P. sativum* have been bred. Widely cultivated examples include: 1) *Pisum sativum* var. *macrocarpon* is commonly known as the Snow pea and 2) *Pisum sativum* var. *macrocarpon* ser. cv. is known as the sugar snap pea (Wikipedia, 2023a). There are three different types of peas, each suited to different ways of eating them - snap peas, snow peas, and shelling peas. 1) Snap peas have fat, juicy and sweet edible pods. Some of these varieties are so sweet they're like candy! If you're looking for an addictive, healthy snack straight out of the garden, this is the type to grow. Kids especially love them. These are usually the earliest peas to mature, as some can be ready to pick in less than 60 days from planting (STS, 2023). 2) Snow peas have edible pods like snap peas, except they are flatter, with smaller seeds. These are the peas you usually see in Asian-style stir fries. They are also great sauteed in butter or fresh in salads (STS, 2023). And 3) Shelling peas, sometimes called "English" peas or simply "garden peas," have fibrous, inedible pods. You only eat the seeds inside. These peas are particularly well suited to freezing and canning, so they are the peas that many of us grew up eating. But make no mistake, a batch of homegrown, fresh-picked shelling peas bears no

resemblance to the canned green mush you were forced to eat before you could have dessert! They are fantastic when quickly sauteed in butter, mixed into a pasta dish, or even pureed on top of toast (STS, 2023).

Pisum is an ancient Latin name for the well-known pea. *Sativum* means "planted," or, more literally, "that which is sown" (Burnham *et al*., 2013). The term *pea* originates from the Latin word *pisum*, which is the latinisation of the Greek πίσον (*pison*), neuter of πίσος (*pisos*) "pea". It was adopted into English as the noun *pease* (plural *peasen*), as in pease pudding (Wikipedia, 2023). Pea *(Pisum sativum)* gets its English name indirectly from the Latin *pisum.* In AngloSaxon the word became *pise* or *pisu*; later, in English it was "pease." So many people thought pease was plural that they persisted in dropping the "s" sound, thus making the word "pea." The Latin name resembles the older Greek *pisos*, or *pison.* Many different species have long been called "pea," so that this word alone is not definite. In much of our own South today "peas" usually means some edible variety of cowpeas. In referring to what most of the United States understands as "peas" (*P. sativum),* the southerner says "English peas" (TAMU, 2023).

Field pea, pea, garden pea, pea, petit-pois, Sugar pea, pea pod, snap pea, snow pea, mange-tout (Messiaen, *et al*., 2006). Common Names of pea are dry pea, Chinese pea, Chinese pea pod, Chinese snow pea, edible pod pea, podded pea, snow pea, sugar snap pea (Burnham *et al.,* 2013). Green "garden" peas, eaten immature and fresh, were an innovative luxury of Early Modern Europe. In England, the distinction between field peas and garden peas dates from the early 17th century. Modern split peas, with their indigestible skins rubbed off, are a development of the later 19th century (Wikipedia, 2023). As one of the most ancient crops in the world,pea played an important role in the introductionof agriculture in post-glacial Europe, often representing the main pulse in the diets of local communities across the continent. It is consumed as fresh vegetable or dry seed throughout the world. It is also one of the most popular vegetables grown for home use by home gardeners (Amin *et al.,* 2010).

Domesticated about 11,000 years ago or so, peas are an important human and animal food crop cultivated throughout the world (Hirst, 2019). *Pisum sativum* L; 2n=2x=14) also commonly known as English pea or green pea and is a commonly grown leguminous vegetable in the world (Amin *et al*., 2010; Vidhi, 2023). Pea is pollinated due to cleistogamous flower structure and has less than percent out crossing (Amin *et al*., 2010). The seeds are dispersed when the pod reaches maturity and bursts open. It scatters the peas over as wide a distance as it is possible for the plant (Wikipedia, 2023a). A pea, although treated as a vegetable in cooking, is botanically a fruit; the term is most commonly used to describe the small spherical seeds or the pods of the legume *Pisum sativum*. *P. sativum* is an annual plant. It is a cool season crop, planted in winter. The average pea weighs between 0.1 and 0.36 grams. The species is as a fresh vegetable, but is also grown to produce dry peas like the split pea. These varieties are typically called field peas (Wikipedia, 2023a). Peas are annual plants, with a life cycle of one year. They are a cool-season crop grown in many parts of the world; planting can take place from winter to early summer depending on location. The average pea weighs between 0.1 and 0.36 gram. The immature peas (and in snow peas the tender pod as well) are used as a vegetable, fresh, frozen or canned; varieties of the species typically called field peas are grown to produce dry peas like the split pea shelled from a matured pod. These are the basis of pease porridge and pea soup, staples of medieval cuisine; in Europe, consuming fresh immature green peas was an innovation of early modern cuisine (Wikipedia, 2023). Pea (*Pisum sativum*) is a small spherical seed found inside the pod fruit. Botanically, pea pods are fruits since they are developed from the pea's ovary and contain seeds. Inside each pod there are seeds. Peas are annual plants with a life cycle of only one year and are grown in numerous regions around the world since they are cool-season crops. Depending on the region, peas can be planted from winter to early summer (Worldatlas, 2017).

Peas are such a rewarding vegetable to grow. They are one of the earliest crops to mature in the spring and you can use them in all kinds of dishes. In fact, you can eat them right off the vine as a snack in the garden. And since they are legumes, they are as good for the soil as they are for people. Peas are easy enough to grow. The most difficult part of growing peas is choosing what kind you want to grow. There are basically three types of peas: English peas, snow peas, and sugar snap peas. Each goes by multiple names, making the choice all the more confusing. But once you get the differences clear, you will probably want to grow some of each. Here are the three main types of peas to grow in your garden (Iannotti, 2022). Pea, (*Pisum sativum*), also called garden pea, herbaceous annual plant in the family Fabaceae, grown virtually worldwide for its edible seeds. Peas can be bought fresh, canned, or frozen, and dried peas are commonly used in soups. Some varieties, including sugar peas and snow peas, produce pods that are edible and are eaten raw or cooked like green beans; they are popular in East Asian cuisines (Petruzzello, 2023). This pea was first grown only for its dry seed. Some varieties are grown extensively today for the dry seeds for "split peas" for soup. The varieties known until about a thousand years ago had seeds that were much smaller, dark colored, and otherwise different from our garden types (TAMU, 2023).

Peas are cultivated both in agriculture (field peas) and horticulture (garden peas) and are used for both for fodder and food, either grown to full maturity or eaten as a fresh vegetable (Hagenblad *et al.,* 2014). Peas are grown in many countries such as China, India, UK, France, Canada, Peru, Turkey, etc. In India it is grown in states such as Himachal Pradesh, Uttar Pradesh, Punjab, Bihar, Orissa, West Bengal, Assam and many more (TS, 2022). As field pea, it occupies about 0.45 mha area in India, accounting for only about 2% of the total pulse area. About 90% of field peas area and production is limited to Uttar Pradesh alone. In general, area under vegetable peas is on increase. The acreage of vegetable pea in India is 3.5 lakh ha with 2.92 million tons of green pod production. Major production states are UP, Bihar Haryana, Punjab, Himachal Pradesh, Orissa and Karnataka. It is worthwhile to mention that large scale production of vegetable peas for international market is still based largely on old varieties. Arkel introduced in India in 1970s still holds ground and is a household name in vegetable pea growers and consumers (Vidhi, 2023).

The genetic diversity of crop species is the result of natural selection on the wild progenitor and human intervention by ancient and modern farmers and breeders. The genomes of modern cultivars, old cultivated landraces, ecotypes and wild relatives reflect the effects of these forces and provide insights into germplasm structural diversity, the geographical dimension to species diversity and the process of domestication of wild organisms (Jing *et al.,* 2010). However, *Lathyrus odoratus,* known also as sweet peas have been cultivated since the 17th century, and there is a wide range of cultivars available commercially. They are grown for the colour of their flowers (which are usually pastel shades of blue, pink, purple, and white) as well as their intense, distinct fragrance. Sweet peas are inedible due to the poisonous seeds. Sweet peas, on the other hand, make lovely flowers for a garden. Except for yellow, the distinctive flowers bear blossoms in a variety of colours. Sweet pea plants come in several sizes, with some having long vines that climb up trellises and poles. Cut flowers are made from the flowers of wine-type sweet pea plants, and bush sweet pea plants have short stalks and do well in flower beds and containers (Vedantu, 2023). If you have heard of sweet peas and confused them with regular green peas, then you are not alone! Even though both terms refer to seeds that grow on plants, the difference between them is that one is inedible, while the other is widely used in the culinary world. Sweet peas (Lathyrus odoratus L.) are flowering plants that grow beautiful white and purple flowers that resemble the wings of a butterfly. To be clear, the seeds produced by this flowering plant are not edible and are poisonous to humans (Wikipedia, 2023b). Peas, like many legumes contain symbiotic bacteria called *Rhizobia* within root

nodules of their root systems. These bacteria have the special ability of fixing nitrogen from atmospheric, molecular nitrogen (N2) into ammonia (NH3). This arrangement means that the root nodules are sources of nitrogen for peas and many legumes, making them relatively rich in plant proteins. All proteins contain nitrogenous amino acids. Nitrogen is therefore a necessary ingredient in the production of proteins. Hence, peas and many legumes are among the best sources of plant protein. When a pea plant dies in the field, for example following the harvest, all of its remaining nitrogen, incorporated into amino acids inside the remaining plant parts, is released back into the soil. In the soil, the amino acids are converted to nitrate (NO3), making the nitrogen available to other plants, thereby serving as fertilizer for future crops (Hai, 2015b).

Sugar pea plants are normally supported. The stems are not twining, but grasp the support with their tendrils. They do not need vertical poles, but the poles can be crossed, or the plants are supported by wire mesh, horizontal wires, vertical lattices or nets, depending on the potential height of the cultivar grown. Garden pea is seldom supported, field pea not at all (Messiaen *et al*., 2006). Sugar pea pods and garden pea seeds are ready for harvesting 8–12 weeks from sowing, field pea seeds one month later. Pods of sugar pea are hand-picked every second day during a 15–20 day period. Garden pea seeds are either handpicked or – in large scale production for canning – machine-harvested. Late harvesting of field pea may result in shedding and rotting of pods and shattering of the seeds. Therefore, harvesting should be done at the appropriate stage: when the leaves begin to yellow, the lower pods begin to wrinkle, and the seed moisture content is reduced to 16–18% (Messiaen, *et al.,* 2006). In this review article on Origin, Domestication, Taxonomy, Botanical Description, Genetics and Cytogenetics, Genetic Diversity, Breeding, Uses, Nutritional Value and Health Benefits of pea are discussed.

ORIGIN AND DOMESTICATION

Central Asia, the Near East, Ethiopia, and the Mediterranean areas are the centers of origin of pea (Kalloo and Bergh, 1993). An abundant presence of the wild taxa of pea, such as red-yellow pea (*Pisum fulvum* Sm.), as well as of beautiful vavilovia (*Vavilovia formosa* (Stev.) Fed.), the closest relative of the genera *Pisum* L. and *Lathyrus* L. (Kenicer *et al.,* 2009), in the local floras of the Near East region, may be regarded as another testimony that it was the very centre of an eventual distribution of pea in all directions. It is considered that the phenomenon of pod dehiscence, present in pea and other related genera, with an ability of shattering the seeds up to 2 m in diameter, significantly contributed to the spreading of these species. Pea seeds were found among the other crops as grave offerings. (Preiss, 2005). The origin and progenitors of *Pisum sativum* are not well known. The Mediterranean region, western and central Asia, and Ethiopia have been indicated as centres of origin. Recently FAO designated Ethiopia and western Asia as centres of diversity, with secondary centres in southern Asia and the Mediterranean region. Archaeological evidence of the use of pea dating from 8000 BC has been found in the Fertile Crescent. The first cultivation of pea appears to have been in western Asia, from where it spread to Europe, China and India. In classical times Greek and Roman authors mentioned its cultivation as a pulse and fodder crop. Pea was already well known in the mountain regions of Central and East Africa before the arrival of the Europeans and was a well-established and important food crop in Rwanda and south-western Uganda by 1860. The use of the edible pods was first described in the Netherlands and France during the 16th century, whereas the use of immature seeds as a vegetable began in Europe a century later (Messiaen *et al.,* 2006). At present, *Pisum sativum* is found in all temperate countries and in most tropical highlands. Field pea is extensively grown in the highlands of eastern Central Africa and East Africa (notably Ethiopia), and in southern Africa. In parts of Rwanda and Uganda it is the main pulse crop. Field pea is hardly grown in West Africa. In Africa garden pea and sugar pea are mostly considered exotic products. They are regionally of some importance, sugar pea more in Francophone countries, garden pea more in Anglophone countries. Imported canned garden pea seeds are available everywhere in food shops (Messiaen *et al.,* 2006). The linguistic evidence supports the fact that pea had been present in nearly all regions of Europe before the modern European language families were developed. Peoples like Indo-Europeans, Turkic, Caucasians or Basques, each have their own words denoting pea, meaning that it preceded the diversification of their own proto-languages into their contemporary descendants (Mikić, 2009).

Pea probably originated in southwestern Asia, possibly northwestern India, Pakistan or adjacent areas of former USSR and Afghanistan and thereafter spread to the temperate zones of Europe. Based on genetic diversity, four centers of origins, namely, Central Asia, the Near East, Abyssinia and the Mediterranean have been recognized. Peas were reported to be originally cultivated as a winter annual crop in the Mediterranean region. Today, this versatile legume is one of the major commercial crops grown all over the temperate, and semi-tropical regions. There are 183 countries growing the peas on the world in 2012. The countries leading in field pea production include: China, India, France, United States of America, Kenya, Egypt, Algeria, United Kingdom, Morocco and Peru (Hai, 2015b). The earliest archaeological findings date back to the Neolithic era in the present day countries of Greece, Syria, Turkey, and Jordan. The crop was cultivated in Egypt from around 4800 – 4400 BC near the Nile delta. They were found in Afghanistan in 2000BC and India around 2250-1750 BC (Worldatlas, 2017). Peas are one of several legumes, and a "founder crop" domesticated in the Fertile Crescent about 11,000 years ago. The earliest human consumption of wild peas was at least 23,000 years ago and perhaps by our Neanderthal cousins as long ago as 46,000 years ago. There are three modern species of peas, and they are very complex genetically and their precise domestication process has yet to be figured out (Hirst, 2019). Peas are one of the oldest cultivated crops. Although the exact origin of domesticated peas has not been traced with complete certainty, the wild plant is native to Mediterranean region. The earliest records of peas date from the late Neolithic era of current Greece, Syria, Turkey, Israel, Iraq, and Jordan. There are records of peas in Harappan civilization and western- and north-western India between 2250–1750 BC (TS, 2022).

The main center of origin and development of this pea is middle Asia, from northwest India through Afghanistan and adjacent areas. A second area of development lies in the Near East, and a third includes the plateau and mountains of Ethiopia. In these areas wild peas of related species have been found, along with a remarkable diversity of cultivated forms of *P. sativum,* but wild *P. sativum* has never been found (TAMU, 2023). The geographical region comprising of Central Asia, the Near East, Abyssinia, and the Mediterranean is considered as center of origin based on genetic diversity. According to Blixt (1970), the Mediterranean is the primary centre of diversity with secondary centres in Ethiopia and the Near East. The genus *Pisum* comprises of only a small number of taxa. All taxa within *Pisum* are diploid (2n = 2x = 14) and the majority are fully inter-crossable with a few being more difficult, but possible. *Pisum humile* syn. *syriacum* is considered a possible candidate as progenitor, as it resembles closely to the cultivated form. There has been introgression to cultivated types from *P. humile* and *P. elatius* (Vidhi, 2023). While the origins of domesticated peas have not been definitely determined, the pea is one of the oldest cultivated crops. The wild plant is native to the Mediterranean region, and ancient remains dating to the late Neolithic Period have been found in the Middle East. European colonization introduced the crop to the New World and other regions throughout the globe. In the mid-1800s, peas in a monastery garden in Austria were famously used by the monk Gregor Mendel in his pioneering studies of the nature of heredity (Petruzzello, 2023).

History: The wild pea is restricted to the Mediterranean Basin and the Near East. The earliest archaeological finds of peas date from the late Neolithic era of current Syria, Anatolia, Israel, Iraq, Jordan and Greece. In Egypt, early finds date from c. 4800–4400 BC in the Nile delta area, and from c. 3800–3600 BC in Upper Egypt. The pea was also present in Georgia in the 5th millennium BC. Farther east, the finds are younger.

Peas were present in Afghanistan c. 2000 BC, in Harappan civilization around modern-day Pakistan and western- and northwestern India in 2250–1750 BC. In the second half of the 2nd millennium BC, this legume crop appears in the Ganges Basin and southern India. In early times, peas were grown mostly for their dry seeds. From plants growing wild in the Mediterranean Basin, constant selection since the Neolithic dawn of agriculture improved their yield. In the early 3rd century BC, Theophrastus mentions peas among the legumes that are sown late in the winter because of their tenderness. In the first century AD, Columella mentions them in *De re rustica*, when Roman legionaries still gathered wild peas from the sandy soils of Numidia and Judea to supplement their rations. In the Middle Ages, field peas are constantly mentioned, as they were the staple that kept famine at bay, as Charles the Good, count of Flanders, noted explicitly in 1124 (Wikipedia, 2023).

Cave men ate primitive peas: Seeds of primitive peas have been found in lake mud beneath the positions of houses of the Swiss lake dwellers, dating back perhaps 5,000 years to the Bronze Age. Peas also were found buried in a cave in Hungary, believed by some to date back even further. Despite recurrent claims, this species of pea has not been found among any of the ancient Egyptian treasures, but it has been found in diggings on the site of ancient Troy. The Aryans from the East are supposed to have introduced peas to the Greeks and Romans, who grew them before the Christian Era. Greek and Roman writings indicate that the crop was held in no special favor. There is no hint of "green peas" until after the Norman Conquest of England. In the 12th century, among other foods stored at the famous old Barking Nunnery, near London, were "green peas for Lent." Nothing really definite was recorded about them, however, until 1536, when they were described in detail in France. The edible-podded pea was also known at that time. Before the end of the 16th century, botanists in Belgium, Germany, and England described many kinds of peas-tall and dwarf, with white, yellow, green seed colors; smooth, pitted, and wrinkled seeds. Garden peas were not common until the 18th century. Toward the end of the 17th century they were still such a rare delicacy that fantastic prices were sometimes paid for them in France. "This subject of peas continues to absorb all others," Madame de Maintenon wrote in 1696. "Some ladies, even after having supped at the Royal Table, and well supped too, returning to their own homes, at the risk of suffering from indigestion, will again eat peas before going to bed. It is both a fashion and a madness." The English developed fine varieties; hence the common designation "English peas" in America. About a hundred years ago the famous Austrian monk, Gregor Johann Mendel, was working with peas in laying the foundation of the modern science of genetics (TAMU, 2023).

TAXONOMY

Pea (*Pisum sativum* L.) belongs to the Family Fabaceae, subfamily Faboideae , genus *Pisum* and species *Pisum sativum* L. (Hai, 2015a**; Hai, 2015b;** Wikipedia, 2023; Wikipedia, 2023a). Family Fabaceae (Leguminosae) includes about 650 genera and ca. 18,000 species: distributed worldwide, 29 tribes (three or four introduced), 167 genera (one endemic, 32 or 33 introduced), and 1,673 species (690 endemic, 131–134 introduced) in China (Wan dou shu *et al*., 2005). *Pisum* comprises a few species and is related to *Lathyrus*, *Lens* and *Vicia*, from which it can be distinguished by its terete stems, very large stipules and longitudinally grooved style. *Pisum sativum* has long been studied by geneticists; Knight did his crossing experiments on it in 1787, and it was the subject of the pioneering work of Gregor Mendel in the 19th century. Within *Pisum sativum* several varieties or subspecies have been distinguished. A classification in cultivar groups is more appropriate. *Sativum* Group is cultivated worldwide, including tropical Africa. *Abyssinicum* Group (Abyssinian pea) is cultivated in the northern (Tigray and Wollo) and south-eastern (Arsi) parts of Ethiopia; it is also grown in Yemen. The latter differs in having leaves with only one pair of leaflets (*Sativum* Group: 2–3 pairs), and smaller, red-purple flowers. It has slightly glossy seeds with a black hilum; these may mature earlier. Other cultivar groups, varieties or subspecies occur outside Africa; 2 of these represent wild populations from southern Europe and western Asia. Purple coloured flowers are associated with bitter tasting green seeds. For this reason nearly all garden pea cultivars are white-flowered, while most field pea cultivars are purple-flowered and sugar pea cultivars can have white or purple flowers (Messiaen *et al*., 2006). The term "Pea" originates from the Latin word *pisum*, which is the latinisation of the Greek πίσον (*pison*), neuter of πίσος (*pisos*) "pea". It was adopted into English as the noun *pease* (plural *peasen*), as in pease pudding. However, by analogy with other plurals ending in *-s*, speakers began construing *pease* as a plural and constructing the singular form by dropping the *-s*, giving the term *pea*. This process is known as back-formation. The term "pea" can refer to small spherical seed or to the pod. The name "peas" is also used to describe other edible seeds from the Fabaceae, such as chickpeas (*Cicer arietinum*), pigeon peas (*Cajanus cajan*), cowpeas (*Vigna unguiculata*), and sweet peas (several *Lathyrus* spp.), which are grown as ornamentals. The name *marrowfat pea* for mature dried peas is recorded by the *Oxford English Dictionary* as early as 1733. The fact that an export cultivar popular in Japan is called *Maro* has led some people to assume mistakenly that the English name *marrowfat* is derived from Japanese (Hai, 2015b).

The Genus *Pisum* L. contains one to five species, depending on taxonomic interpretation; the International Legume Database (ILDIS) accepts three species, one with two subspecies **(**Hai, H.D. 2015; Hai, 2015a; Hai, 2015b):

1- Species *Pisum abyssinicum* (syn. *Pisum sativum* subsp. *abyssinicum* or *Pisum sativum var. abyssinicum*) is a Legume described by Alexander Karl Heinrich Braun. *Pisum abyssinicum* included in the genus *Pisum* L. of the Legume Family (Fabaceae).
2- Species *Pisum fulvum*. *Pisum fulvum* is a species of the Genus *Pisum* L. in the Tribe Fabeae of the Legume Family (Fabaceae). English name: Wild pea; Synonyms: *Pisum fulvum* var. *amphicarpum* Warb. & Eig.
3- Species *Pisum sativum* - Common pea, Garden pea, Field pea, pea

Pisum sativum, the common pea (also known as the garden or field pea), is an herbaceous annual in the Fabaceae (formerly Leguminosae) family, originally from the Mediterraean basin and Near East, but now widely grown for its seedpod or legume (a simple dry fruit containing several seeds and splitting along seams on two sides). The term "pea" can refer to small spherical seed or to the pod. The name "peas" is also used to describe other edible seeds from the Fabaceae, such as chickpeas (*Cicer arietinum*), pigeon peas (*Cajanus cajan*), cowpeas (*Vigna unguiculata*), and sweet peas (several *Lathyrus* spp.), which are grown as ornamentals. The wild pea is restricted to the Mediterranean basin and the Near East. The earliest archaeological finds of peas date from the late neolithic era of current Greece, Syria, Turkey and Jordan. In Egypt, early finds date from *ca.* 4800-4400 BC in the Nile delta area, and from *ca.* 3800-3600 BC in Upper Egypt. The pea was also present in Georgia in the 5th millennium BC. Farther east, the finds are younger. Peas were present in Afghanistan *ca.* 2000 BC, in Harappa, Pakistan, and in northwest India in 2250-1750 BC. In the second half of the 2nd millennium BC, this pulse crop appears in the Gangetic basin and southern India. *Pisum sativum* is an annual plant, with a life cycle of one year. It is a cool season crop grown in many parts of the world; planting can take place from winter to early summer depending on location. The average pea weighs between 0.1 and 0.36 grams. The immature peas (and in snow peas the tender pod as well) are used as a vegetable, fresh, frozen or canned; varieties of the species typically called field peas are grown to produce dry peas like the split pea shelled from the matured pod. These are the basis of pea porridge and pea soup, staples of medieval cuisine; in Europe, consuming fresh immature green peas was an innovation of Early Modern cuisine. *Pisum sativum* (the field or garden pea), is domesticated and is a major human food crop. There are two subspecies, viz.,

1) *Pisum sativum* subsp. *elatius* (syn. *Pisum elatius*, *Pisum syriacum*)
2) *Pisum sativum* subsp. *sativum*

There are six species of peas (Kalloo and Bergh, 1993):

Pisum sativum (garden pea),
P. elatius (Mediterranean pea),
P. arvense (field pea),
P. abyssinicum (Abyssinian pea),
P. humile (dwarf pea), and
P. fulvum (red yellow pea)

Hai (2015b) reported 6 species:
Lathyrus oleraceus Lam.
Pisum arvense L.
Pisum biflorum Raf.
Pisum elatius M.Bieb.
Pisum humile Boiss. & Noe
Pisum vulgare Jundz.

Wikipedia (2023) reported 6 species:

Lathyrus oleraceus Lam.
Pisum arvense L.
Pisum biflorum Raf.
Pisum elatius M.Bieb.
Pisum humile Boiss. & Noe
Pisum vulgare Jundz.

Subspecies/varieties recognized (Burnham *et al*., 2013)

P. sativum L. subsp. abyssinicum (A. Braun) Govorov
P. sativum L. subsp. elatius
P. sativum L. *subsp. elatius pumilio*
P. sativum L. var. *hortense* Asch. & Graebn.
P. sativum L. *subsp. Sativum*

Botanical Subspecies/varieties recognized/ synonyms (Burnham *et al*., 2013)

P. arvense L.
P. humile Boiss. & Noe
P. sativum L. ssp. *arvense* (L.) Poiret
P. sativum L. var. *arvense* (L.) Poir.
P. sativum L. var. *humile* Poir.
P. sativum L. var. *macrocarpon* Ser.

Three species of peas are known today (Hirst, 2019):

- *Pisum sativum* L. extends from Iran and Turkmenistan through anterior Asia, northern Africa, and southern Europe
- *P. fulvum* is found in Jordan, Syria, Lebanon, and Israel
- *P. abyssinicum* is found from Yemen and Ethiopia

Iannotti (2022) reported three types of peas:

1) English Peas (*Pisum sativum*, var. *sativum*): English peas do not have edible pods; you have to wait until fully plumped up before shelling and eating them. Shelling peas are one of the fastest maturing types of peas, with the smaller, bush varieties ready in about 50 days.

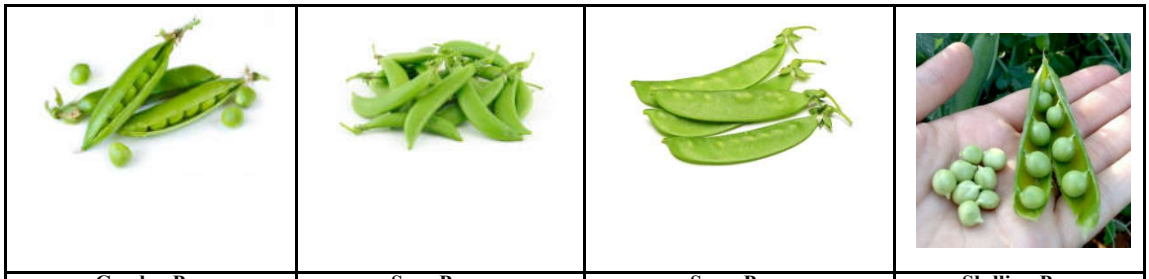
2) Snow Peas (*Pisum sativum* var. *saccharatum*): Snows peas, often referred to as Chinese pea pods, have flat edible pods; the seeds are not allowed to fill out before harvesting. Even though you do not have to wait for the peas inside to plump, snow peas tend to have the longest days to maturity of all the peas, especially the tall varieties.

3) **Sugar Snap Peas (*Pisum sativum* var. *marcrocarpon*):** Sugar snap peas are a cross between English peas and snow peas. As with English peas, the seeds are allowed to plump up a bit. However, the pods are crisp and edible, so they do not need to be shelled and are used in recipes in the same way as snow peas. Sugar snap peas are grown the same way as English peas, but they tend to last a bit longer when the weather warms up.

While there are hundreds of varieties of peas, there are 3 main types of peas viz., English Peas (Garden Peas), Sugar Snap Peas and Snow Peas. There are quite a few differences between English and Sugar Snap peas, and of course Snow peas. Here is a quick overview of the differences (Chenell, 2022):

	English Peas	Snow Peas	Sugar Snap Peas
Also Called	– Garden peas – Green peas – Sweet peas	Chinese pea pods	Snap peas
Summary	The most iconic-looking pea, that most people think of	A flatter version of sugar snap peas	Cross between snow and garden peas
Shape	Full pods with round peas inside	Flat pods with small peas inside	More rounded pods with smaller peas
Edible Pod	No	Yes; tough strings on edges	Yes
Best For	All types of cooking; these are the "common" peas you'll find at the store	Stir fries	Salads and stir fries, or eaten raw
Flavor	Sweet	Not as sweet as sugar snaps	Sweeter than snow peas

PD (2023) reported three types of peas: Garden peas are typically 3-4 inches long and have tough pods that aren't recommended for eating. However, these pods contain sweet, tender peas, which are perfect for adding to stir fries and soups, cooked on their own as a simple side dish or even eaten raw in a salad. Smaller, even more tender garden peas are often known as petite pois. Snow peas are flat with small peas inside. They are tender and unlike the garden pea, the entire vegetable is enjoyable to eat. Two to three inches in length, they're ends are commonly trimmed and then they are used whole in stir-fries or blanched with some butter. They are also delicious eaten raw as a snack or added to a salad or vegetable tray. Snap peas are a cross between garden peas and snow peas! That's how they get their tender crisp outer pods, and sweet inner peas. Some snap pea varieties are stringless like snow peas, while others may need some trimming before they are ready to eat. Like snow peas, they are enjoyed raw or lightly cooked in a variety of dishes.



Garden Peas	Snap Peas:	Snow Peas:	Shelling Peas

Fig.1. Pod types in peas

STS (2023) reported three types of Peas: Snap peas have fat, juicy and sweet edible pods. Some of these varieties are so sweet they're like candy! If you're looking for an addictive, healthy snack straight out of the garden, this is the type to grow. Kids especially love them. These are usually the earliest peas to mature, as some can be ready to pick in less than 60 days from planting. Snow peas have edible pods like snap peas, except they are flatter, with smaller seeds. These are the peas you usually see in Asian-style stir fries. They are also great sauteed in butter or fresh in salads. Shelling peas, sometimes called "English" peas or simply "garden peas," have fibrous, inedible pods. You only eat the seeds inside. These peas are particularly well suited to freezing and canning, so they are the peas that many of us grew up eating. But make no mistake, a batch of homegrown, fresh-picked shelling peas bears no resemblance to the canned green mush you were forced to eat before you could have dessert! They are fantastic when quickly sauteed in butter, mixed into a pasta dish, or even pureed on top of toast.

TS (2022) reported four types of peas:

Garden peas: The average height of garden peas is 1 m.
Sugar Peas: Sugar peas do not have the tough membrane inside the pod wall and have tender edible pods.
Snow peas and snap peas both are the types of sugar peas.
Field Peas − Field pea is one of the oldest domesticated crops. They come in multiple colors such as blue, white, maple, and brown. It is a climbing species with weak, viny, and relatively succulent stems. The vines can be about 1.5 m long.

There are two notable variations on the common pea (Archer, 2023):

The snow pea and the sugar snap pea. Snow peas are known scientifically as *Pisum sativum v. saccharatum*. Snow peas differ from the typical pea in that the pea pods have a whitish hue, as opposed to the typical green. Snow peas grow best toward the end of winter and can survive harsh snows, hence the name. Sugar snap peas are known as *Pisum sativum v. macrocarpon*. Some pea varieties present as a bush; sugar snap cultivars grow as a pea vine. Sugar snap peas require support in the form of a trellis or other climbing system in order to thrive. Sugar snap peas are more adaptable than other pea plant types because they are able to grow in warmer temperatures than other pea types. The snap pea is a type of edible-podded pea that is conspecific to field and garden peas (*P. sativum* L.). Edible-podded peas lack pod parchment or fibre. Most snap pea cultivars have wrinkled seeds with green cotyledons, white flowers and short internodes.

The phylogenetic tree: *P. sativum* is part of the family of legumes known as the IRLC or the Inverted Repeat-Lacking Clade. It is related to other legumes such as beans, lentils, peanuts, soybeans, and lima beans. Although there are many other types of legumes that are related to the garden pea. Peas, in general, can also be broken into groups such as the starchy peas and sweet peas. Starchy peas are commonly referred to as green split peas, yellow split peas, blue pea capucijners, marrowfat peas, and tall telephone peas. The sweet peas category is recognized to contain English peas, snow peas, and sugar snap peas. This tree below was created by looking at various genetics connections. The group that put the tree together was not looking at one specific characterization to develop their "Tree of Life." The basis of the tree was put together by numerous biologist and experts in their specific area (Bioweb, 2008).

Mendel and his pea plants: People have long known that the characteristics of living things are similar in parents and their offspring. Whether it's the flower color in pea plants or nose shape in people, it is obvious that offspring resemble their parents. However, it wasn't until the experiments of Gregor Mendel that scientists understood how characteristics are inherited. Mendel's discoveries formed the basis of **genetics**, the science of heredity. That's why Mendel is often called the "father of genetics." It's not common for a single researcher to have such an important impact on science. The importance of Mendel's work was due to three things: a curious mind, sound scientific methods, and good luck. You'll

see why when you read about Mendel's experiments. Gregor Mendel was born in 1822 and grew up on his parents' farm in Austria. He did well in school and became a monk. He also went to the University of Vienna, where he studied science and math. His professors encouraged him to learn science through experimentation and to use math to make sense of his results. Mendel is best known for his experiments with the pea plant *Pisum sativum*. The Austrian monk Gregor Mendel experimented with pea plants. He did all of his research in the garden of the monastery where he lived (CKFoundation, 2022).

Blending theory of inheritance: During Mendel's time, the blending theory of inheritance was popular. This is the theory that offspring have a blend, or mix, of the characteristics of their parents. Mendel noticed plants in his own garden that weren't a blend of the parents. For example, a tall plant and a short plant had offspring that were either tall or short but not medium in height. Observations such as these led Mendel to question the blending theory. He wondered if there was a different underlying principle that could explain how characteristics are inherited. He decided to experiment with pea plants to find out. In fact, Mendel experimented with almost 30,000 pea plants over the next several years! Why did Mendel choose common, garden-variety pea plants for his experiments? Pea plants are a good choice because they are fast-growing and easy to raise. They also have several visible characteristics that may vary. These characteristics, which are shown in the **Fig.** 2 include seed form and color, flower color, pod form and color, placement of pods and flowers on stems, and stem length. Each characteristic has two common values. For example, seed form may be round or wrinkled, and flower color may be white or purple (violet) (CKFoundatio, 2022)

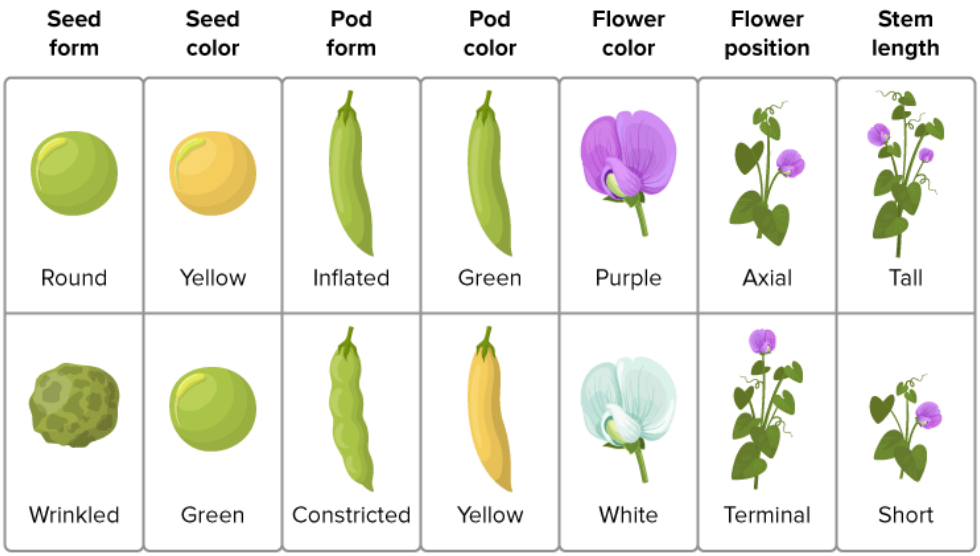


Fig. 2. Mendel investigated seven different characteristics in pea plants.

Studying peas: Peas were one of the first plants studied by geneticists, starting with Thomas Andrew Knight in the 1790s, not to mention the famous studies by Gregor Mendel in the 1860s. But, interestingly enough, mapping the pea genome has lagged behind other crops because it has such a large and complex genome. There are important collections of pea germplasm with 1,000 or more pea varieties located in 15 different countries. Several different research teams have begun the process of studying pea genetics based on those collections, but the variability in *Pisum* has continued to be problematic. Israeli botanist Shahal Abbo and his colleagues built wild pea nurseries in several gardens in Israel and compared the grain yield patterns to those of domesticated pea (Hirst, 2019).

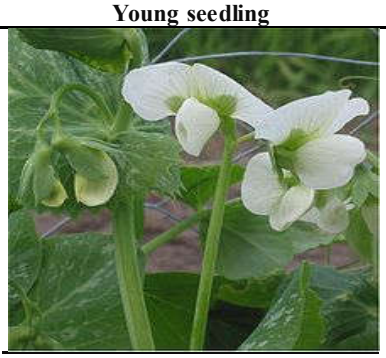
BOTANICAL DESCRIPTION

Pea is an annual herbaceous plant with racemose inflorescences arising from the leaf axils; it is single to multiple podded, and the pods have 5 to 10 seeds (Kalloo and Bergh, 1993). Pea is a herb, annual or perennial. Stem often climbing by means of tendrils, terete, glabrous. Leaves paripinnate with rachis terminating in a tendril; stipules leaflike, cordate, larger than leaflets (to 10 cm); leaflets 1–3-paired, ovate to elliptic, margin entire or dentate. Inflorescence a 1 to many flowered raceme. Calyx campanulate; teeth ± leaflike, at least 2 teeth less than 2 × as long as tube. Corolla white or otherwise colored; standard obovate. Stamens diadelphous; staminal tube not oblique at apex; filaments distally slightly dilated. Ovary subsessile; ovules many; style curved inward, distally dilated and margin recurved forming a laterally compressed body, longitudinally grooved, hairy on upper side. Legume long elliptic, inflated, apex acute. Seeds many, spheroid (Wan dou shu et al., 2005). Pea plant is an annual, climbing, glabrous herb up to 2(–3) m tall (up to 1.3 m for sugar pea types); taproot well developed, up to 1.2 m long, with many lateral roots; stem terete, with no or few basal branches, internodes hollow. Leaves alternate, pinnate, with 1–3(–4) pairs of leaflets and ending in a usually branched tendril; stipules leaf-like, up to 8(–10) cm × 4 cm; petiole (2–)4–6 (–7.5) cm long; leaflets shortly stalked, ovate to elliptical, 1.5–8 cm × 0.5–4 cm, entire to toothed, sometimes converted into tendrils. Inflorescence an axillary, 1–3-flowered raceme. Flowers bisexual, papilionaceous; calyx with tube 4–8 mm long, lobes as long or longer than tube; corolla white to purple, standard 1–3 cm × 2.5–4.5 cm, wings a little shorter than standard, keel much shorter; stamens 10, 9 united and 1 free; ovary superior, 1-celled, style curved, longitudinally grooved. Fruit an oblong-ovate pod 3.5–15 cm × 1–2.5 cm, pendant, 2–11-seeded. Seeds globose, sometimes wrinkled, 5–8 mm in diameter, varying in colour from uniform yellow (sugar pea), green (crinkled garden pea) to purple or spotted or cream-white, sometimes with black hilum. Seedling with hypogeal germination; cotyledons remaining within testa; first 2 leaves simple. Pea is propagated by seed. The 1000-seed weight ranges from 100 g to 500 g (Messiaen *et al.*, 2006).

This glabrous, herbaceous vine has leaves that are alternate and pinnately compound. The leaflets are ovate, entire, 1.5 – 6 cm long and 1-4cm broad. There are 1–4 pairs of pinnately-veined leaflets per side with the terminal leaflet pair modified into a branched tendril. Leaflets are essentially sessile. The stipules are large, up to 10cm long (usually 1.5-8 cm), on round, slender, and glabrous stems. The midrib of the leaf rachis can be slightly winged. This plant climbs using the tendrils produced at the apex of a compound leaf. These modified terminal leaflets form a branched tendril (pers. obs.). Flowers are borne on axillary racemes of 1-3 flowers, each 1.5-3.5cm long. Calyx is campanualte (8-15mm) with teeth exceeding the tube in length. Corollas can be white, pink, or purple. Flowers have the classic "Faboid legume" form with 5 sepals, 5

zygomorphic petals (bilaterally symmetrical), 10 stamens in two groups (9 fused + 1 free) and a single superior carpel (pers. obs., SY). The standard petal is obovate, 1.6-3cm long and the glabrous ovary is nearly sessile. The style is flattened, curved, grooved longitudinally, and pubescent adaxially. Self-pollination is possible in this species, but bees are also visitors. The fruit is a legume. These are borne on a short pedicel, are 4-15 cm long and 1.5-2.5cm wide. The fruits are dehiscent both adaxially and abaxially, with each pod containing 2-10 seeds. Seeds morphology varies greatly. They can be smooth or wrinkled, and globose or angled. Colors range from white to grey, green, or brown. Mature seeds are without the typical endosperm of most angiosperms and the cotyledons serve a nutritive role for the germinating seed. The pea is a widely distributed crop species but has rarely been encountered as an invasive and thus little is written about its dispersal. Pea fruits left on the vine may open along both sutures, dispersing seed by gravity but wild observations could not be found (Burnham et al., 2013). *Pisum sativum* is an annual plant, with a life cycle of one year. It is a cool season crop grown in many parts of the world; planting can take place from winter to early summer depending on location. *Pisum sativum* cultivars are either low growing (less than 0.75 meters) or vining. The vining cultivars grow thin tendrils from leaves that coil around any available support and can climb to be 1-2 m high. Pea is a quick growing, annual herbaceous vine which requires trellis to support its growth. It flourishes under well-drained, sandy soil supplemented with adequate moisture and cool weather conditions. Short stalked, green pods appear by late winter or early spring. The leaves are alternate, pinnate with 1-3 pairs of leaflets and a terminal branched tendril leaflets ovate or elliptic, 1.5-6 cm long. Stipules are large, leaf-like and up to 10 cm long. The leaf type could be conventional, semi-leafless and leafless. Leaf size in most cases increases up to the first node bearing the first flower. The inflorescence of pea is a raceme arising from the axil of the leaf. Flowers borne on the same peduncle produce pods that mature at different times, the youngest being at the tip. On a whole plant basis, flowering is sequential and upwards from node to node. The node at which the first flower emerges is characteristic of a given variety; in temperate regions the number of nodes at which the first flower emerges is reported to vary from 4 in the earliest to about 25 in late maturing types under field conditions. The distinctive flower has 5 fused sepals, 5 petals, 10 stamens (9 fused in a staminal tube and 1 stamen is free), and one carpel, which develops into a pod with multiple peas. Corolla is white, or pink, or purple. Pea is a self pollinated annual herb. The fruit is called pod. Pea pods are botanically fruit, since they contain seeds and developed from the ovary of a (pea) flower. Each pod measures about 4-15 cm long, 1.5-2.5 cm wide, swollen or compressed, straight or slightly curved, filled with single row of 2-10 light-green, smooth edible seeds. Each pod contains several seeds called peas. A pea seed is a most commonly green, occasionally golden yellow, or infrequently purple pod-shaped. Seeds are globose or angled, smooth or wrinkled, exalbuminous, whitish, gray, green, or brownish. The average pea weighs between 0.1 and 0.4 grams. It germinates cryptocotylarly. Many cultivars reach maturity about 60 days after planting and 100 days to mature the dry seed (Hai, 2015b).

Peas are hardy leafy annual plants. There are both low-growing and vining cultivars. The pea plants have hollow trailing or climbing stems. The stems have terminal tendrils which help in climbing. These tendrils can coil around any available support and can climb to be 1–2 meters high. Usually, woody tree branches are thrust upright into soil near pea plants in order to provide them lattice for climbing. The pea plants bear compound leaves with three pairs of leaflets. The pea flowers are butterfly-shaped and can be white, pink, purple or reddish in color. Usually there are 2–3 three flowers per stalk. The pea plants can pollinate by themselves. The fruit is a pod containing 5–10 seeds attached by short stalks. This pod can grow to 10 cm long (TS, 2022). Habit: Cultivated herb, becoming shrubby. Root: Branched tap root system, nodulated due to the presence of nitrogen fixing bacteria (*Rhizobium leguminosorum).* Stem: Erect and climbing, one to three feet high, young stem densely pubescent, somewhat angular, herbaceous, green and branched. Leaves: Alternate, petiolate, stipulate, stipules ¼ to ½ inch long attached near the base, compound (trifoliate), leaflets dark green, entire, acuminate, pubescent on both the sides, reticulate venation. Inflorescence: Clustered axillary racemes. Flower: Bracteate (small and deciduous), bracteolate (usually persistent), pedicellate, heterochlamydeous, complete, bisexual, pentamerous, zygomorphic and hypogynous. Calyx: Sepals 5, green synsepalous, companulate, showing valvate aestivation. Odd sepal is anterior in position. Corolla: Petals 5, apopetalous, irregular papillionaceous, consisting of a posterior standard, two lateral wings, two anterior ones forming a keel which encloses stamen and pistil, vexillary / descendingly imbricate aestivation. Androecium: Stamens 10, diadelphous (9)+1 nine stamens fused to form a bundle and the tenth one is posterior and free. Anthers dithecous, basifixed, introse and dehisce longitudinally. Gynoecium: Monocarpellary, ovary superior, unilocular, with many ovules on marginal placentation, style simple and curved, stigma capitate. Fruit: Legume. Seed: non-endospermous with thick cotyledons (Fig. 3 & 4) (Brainkart, 2023).

<table>
<tr><td>  </td><td>  </td><td>  </td></tr>
<tr><td>Germination of seed</td><td>Young seedling</td><td>Plants</td></tr>
<tr><td>  </td><td>  </td><td>  </td></tr>
<tr><td>Plants with flowers</td><td>Flowers</td><td>Flower</td></tr>
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Continue ….

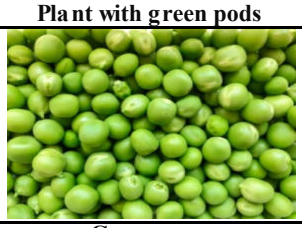
		
Plant with pink flower	Pink flower	Purple flower
		
Plant with green pods	Pods with seeds	Field pea /Purple pods
		
Green peas	Frozen green peas	
		
Dried pods and seeds	Dry seeds	Dried seeds

Fig. 3: Botanical Description

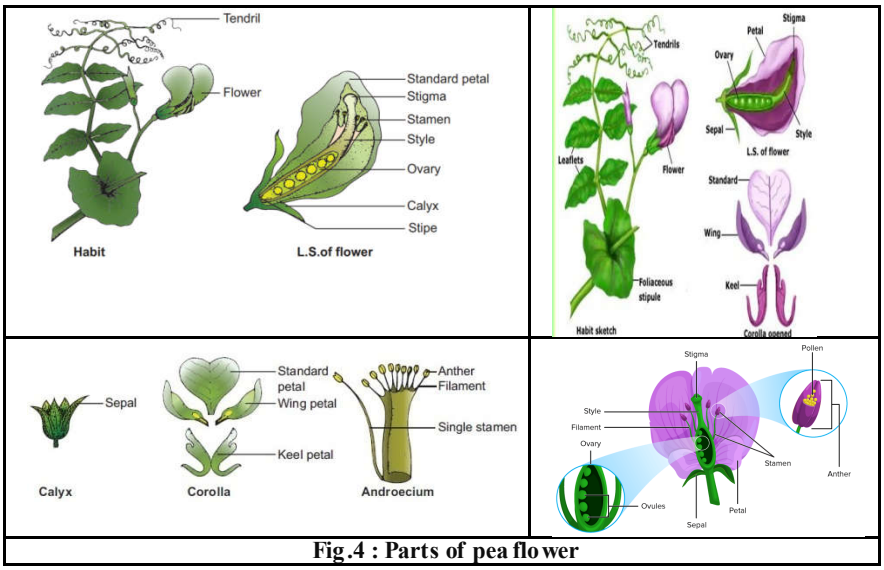


Fig.4 : Parts of pea flower

Peas have both low-growing and vining cultivars. The vining cultivars grow thin tendrils from leaves that coil around any available support and can climb to be 1 to 2 metres high. A traditional approach to supporting climbing peas is to thrust branches pruned from trees or other woody plants upright into the soil, providing a lattice for the peas to climb. Branches used in this fashion are called pea sticks or sometimes pea brush. Metal fences, twine, or netting supported by a frame are used for the same purpose. In dense plantings, peas give each other some measure of mutual support. Many cultivars reach maturity about 60 days after planting (Wikipedia, 2023). It is a climbing annual legume with weak, viny, and relatively succulent stems. Vines often are 4 to 5 feet (120 to 150 cm) long, but when grown alone, field pea's weak stems prevent it from growing more than 1.5 to 2 feet (45 to 60 cm) tall. Leaves have two leaflets and a tendril. Flowers are white, pink, or purple. Pods carry seeds that are large (4,000 seeds/lb), nearly spherical, and white, gray, green, or brown. The root system is relatively shallow and small, but well nodulated (Wikipedia, 2023). Pea is an annual herbaceous plant. It has a tap root system. Stems are slender, usually single, and upright in growth. Leaves are pinnately compound with two to several leaflets. The rachis terminates in a simple or branched tendril. There are large stipules at the base of leaf. The plant may be single stemmed or many axillary stems may originate at the cotyledonary node or any superior node, especially if the apical growing point is destroyed, leaflets of a pair are opposite or slightly alternate. The lower leaflets are larger than the upper leaflets. The margins of leaflets and stipules may be entire or serrated. The inflorescence is raceme arising from the axil of a leaf. The lowest node at which flower initiation occurs, is normally constant under a given set of conditions and is used in classifying the varieties into early and late types. Most early cultivars produce the first flower from nodes 5 to 11 and the late cultivars start flowering at about nodes 13 to 15. Early cultivars are often single flowered or bear some single and some double flowers. Late cultivars are usually double/triple flowered. The flowers are typical papilionaceous with green calyx comprising of five united sepals, five petals (one standard, two wings and two keels). The stamens are in diadelphous (9+1) condition. Nine filaments are fused to form a staminal tube, while the tenth is free throughout its length. The gynoecium is monocarpellary, with ovules (up to 13) alternately attached to the two placentas. Style normally bends at right angle to the ovary. Stigma is sticky. Pea is strictly self-pollinated in nature. Stigma is receptive to pollen from several days prior to anthesis until 1 day or more after the flower wilts. Pollen is viable from the time anthers dehisce till several days thereafter. For emasculation, the flower bud chosen should have developed to the stage just before anther dehiscence, indicated by extension of petals beyond sepals. Flowers can be emasculated at any time. The first step in emasculation is to tear away with the forceps the tip of the sepal from in front of the keel. The forefinger is positioned behind the flower and thumb in front and a light pressure is applied. This spreads the standard and wings to expose the keel. The exposed keel is slit-open by tips of forceps. Pressure can be applied by the thumb and finger on keel for increased exposure of the pistil and stamens. The 10 stamens are pulled out. Pollen can be obtained throughout the day, preferably from a freshly opened flower. For pollen collection, it is more convenient to pick the male flowers, remove the standard and wings, pull back the keel so that the style protrudes and use the pollen covered stylar brush as an applicator to transfer the pollen to the stigma of the emasculated bud. Older flowers and other flower buds not used in crossing are removed from the peduncle to increase the pod set after crossing. Normally emasculation is done in afternoon followed by pollination next forenoon/morning. The somatic chromosome number of peas is 14 . The translocations and other chromosome arrangements are common (Vidhi, 2023).

The tiny spherical seed or seed-pod of the pod fruit *Pisum sativum* is known as the pea. Peas may be green or yellow, and each pod contains many peas. Peapods are called fruit by botanists since they contain seeds and grow from the ovary of a (pea) flower. *Pisum sativum* is an annual plant that has a one-year life cycle. It's a cool-season crop that's grown all over the world; depending on where you live, you can plant it anywhere from winter to early summer. A pea weighs between 0.1 and 0.36 grams on average. Immature peas (and the tender pod in snow peas) are used as a vegetable, fresh, frozen, or canned; varieties of the species generally known as field peas are grown to produce dry peas shelled from a matured pod. These are the ingredients in pea porridge and pea soup, which were staples of medieval cuisine; in Europe, eating new immature green peas was an early modern culinary invention. A pea is a pod-shaped vegetable that is usually green but may also be golden yellow or purple. It is widely grown as a cool-season vegetable crop. The seeds can be planted as soon as the soil temperature exceeds 10 degrees Celsius, with the plants growing best at temperatures of 13 to 18 degrees Celsius. Around 60 days after planting, several cultivars attain maturity. Low-growing and vining cultivars of peas are available. Vining cultivars develop thin tendrils from their leaves that coil around any available support and can reach a height of 1–2 meters. Climbing peas are usually supported by thrusting upright branches pruned from trees or other woody plants into the soil, forming a lattice for the peas to ascend. Pea sticks or pea brushes are the terms for the branches used in this fashion. For the same reason, metal fences, twine, or netting supported by a frame are used. Peas owe each other some measure of mutual support in dense plantings. Self-pollination is possible in pea plants (Vedantu, 2023). Pea, *Pisum sativum*, is an annual herbaceous legume in the family Fabaceae grown for its edible seeds and seedpods. The pea plant can be bushy or climbing, with slender stems which attach to a substrate using tendrils. Each leaf has 1–3 pairs of oval leaflets and can reach 1–6 cm in length. The plant produces white, red or purple flowers and swollen or compressed green seedpods which can be straight or curved. The pods can range in size from 4 to 15 cm long and 1.5–2.5 cm wide. Each pod contains between 2 and 10 seeds, or peas. The pea plant is an annual plant, surviving only one growing season and can reach 30–150 cm in height. Pea may also be referred to as garden pea, English pea or green pea and likely originates from Southwest Asia (PV, 2023). Pea plant is a common annual herb cultivated during the winter for the seeds. It is a weak plant and climbs with the help of tendrils. The roots are infected by nitrogen fixing bacteria and they form characteristic nodules. Leaves are pinnately compound (imparipinnate), where the terminal leaflets are modified into tendrils. The leaf-base is swollen, forming pulvinus. A pair of foliaceous stipules is present. Flowers are lateral, solitary or in racemes. They are complete, irregular, zygomorphic, bisexual and slightly perigynous. Calyx is composed of five united sepals. Corolla is papilionaceous, made up of five free petals. The largest and the outermost one is the standard or vexillum, two lateral petals are wings or alae, and the innermost two, called keel or carina, unite to form a boat-shaped body. Aestivation is vexillary. Androecium consists of ten stamens, nine united to form a bundle, one remaining free, diadelphous. Gynoecium is monocarpellary, one-chambered with ovules in two series. Placentation is marginal. Ovary is elongated and superior. Fruit is a legume dehiscing by both the sutures. Seeds are exalbuminous and germination is hypogeal. The plant is the sporophyte; the gametophytes, represented by pollen tube and embryo-sac, are extremely reduced and dependent on the sporophyte (Gupta, 2023).

Harvesting: In general, the harvesting of green pea pods should be done just before they reach complete maturity. The harvesting time for early varieties is about 40–60 days; for mid-season crops it is about 75 days, and for late-season crops it is about 100 days. Multiple pickling is usually done in a given period of time. Within a period of 2– 10 days there could be 4–5 pickling depending on the yield. The yield and quality depend on seed variety and crop management practices. During harvesting, the pea pods are picked by hands. The best way is to use two hands, hold the vine with one hand, and pull the pods with the other hand. Regular harvest helps more pods to develop. Freshly harvested peas have the best flavour. As the plants mature, they stop producing and the plant dies back when the weather becomes hot (TS, 2022).

Controlling Pollination: Pollination is the fertilization step in the sexual reproduction of plants. Pollen consists of tiny grains that are the male gametes of plants. They are produced by a male flower part called the anther. Pollination occurs when pollen is transferred from the anther to the stigma of the same or another flower. The stigma is a female part of a flower. It passes the pollen grains to female gametes in the ovary. Flowers are the reproductive organs of plants. Each pea plant flower has both male and female parts. The anther is part of the stamen, the male structure

that produces male gametes (pollen). The stigma is part of the pistil, the female structure that produces female gametes and guides the pollen grains to them. The stigma receives the pollen grains and passes them to the ovary, which contains female gametes. Pea plants are naturally self-pollinating. In self-pollination, pollen grains from anthers on one plant are transferred to stigmas of flowers on the same plant. Mendel was interested in the offspring of two different parent plants, so he had to prevent self-pollination. He removed the anthers from the flowers of some of the plants in his experiments. Then he pollinated them by hand with pollen from other parent plants of his choice. When pollen from one plant fertilizes another plant of the same species, it is called cross-pollination. The offspring that result from such a cross are called hybrids (CKFoundatio, 2022)

GENETICS AND CYTOGENETICS

The main emphasis in pea improvement has been on early maturity, yield, quality, and resistance to diseases and insect pests. Three single recessive genes, cry, la and le influence internode length and plant height. Each gene governs these characters along with other two genes. Similarly branching is controlled by two single recessive genes, fr and fru in sence of each other. A single recessive gene, ram is responsible for increasing the number of branches. The characters of leaves, leaflets, stipules and tendrils are governed by single recessive genes. Single dominant genes confer resistance to several diseases like Enation mosaic virus (en), Near Wilt, *Fusarium oxysporum* f. pisi race 2 (fnw), *Fusarium* wilt, *Fusarium oxysporum* f. pisi race 1 (fw), Brown root of peas, *Fusarium solani* f. sp. pisi, Rust, *Uromyces fabae*, Downy mildew *Perenospora pisci* and Bacterial blight. *Pseudomonas syringe* pv. pisi race 1. The resistance to Bacterial Brown spot of Pea, *Pseudomonas syringe* pv. pisi, is due to a complex system of inheritance. The highly heritable polygenic characters are plant height, earliness, number of per plant, pod length, seeds per pod and 100 seed weight. Seed yield per plant had additive genetic variance and positive epistatic gene action for seed yield per plant. Days to flowering showed non additive gene action with partial dominance and over dominance. Partial dominance or over dominance were also observed for plant height. Arkel and Bonneville must get priority on the part of vegetable breeders as a challenge to them (Amin *et al.,* 2010).

Qualitative Genes of Pea: Significant contributions on qualitative genetics of peas have been made by several scientists. A partial listing of genes useful in breeding programme has been compiled and is adapted **Table 1** (Vidhi, 2023):

Table 1. Some important qualitative genes of pea

Symbol	Description
1	2
Plant characters	
cry	Influences length of internodes and plant height along with la and ls
la	Influences length of internodes and plant height along with cry and la
ls	Influences length of internodes and plant height along with cry and la
Branching	
ram	Increases number of branches
Leaves and stipules	
af	Leaflets converted to tendrils
cri	Leaves, stipules, flowers, and pods folded and crisp
lat	Double leaflet and stipule area
st	Stipules reduced to strap like structures
tac	Tendrils present on acacia leaves
tl	Leaves with extra leaflets and no tendrils
Wax (bloom)	
wa	Without wax on pods, upper and lower stipule surfaces, and underside of leaflets
was	Reduced wax as with wa
wb	Pods without wax, little wax on rest of plant
wel	Wax absent from all parts of the plant
wex	Extra wax on all acrial plant parts
Colour	
a	Absence of anthocyanin
alb	Plants without chlorophyll, albina, lethal
Inflorescence	
Number of flowers	
fn	With fna determines number of flowers on the inflorescence, greatly influenced by environment
fna	With fn determines number of flowers on the inflorescence, greatly influenced by environment
Pollen colour	
yp	Yellow pollen
Seeds:	
Form	
com	Sides of seeds flattened
r	Seed cotyledons wrinkled
Surface	
gty	Surface texture gritty
Colour	
i	Green cotyledons, I produces yellow cotyledons
Pods	
Breadth	
it	Increases pod width 25%
Form	
Bt	Apex of pods blunt
Con	Affects curvature of pod
Fibre	
Dpo	Pods tough and leathery, readily dehisce at maturity
Colour	
gp	Young pod yellow
Disease resistances:	
Enation mosaic virus	
En	Resistant to enation mosaic virus
Fusarium wilt and near wilt	
Fnw	Resistant to *F. oxysporum* race 2
Fw	Resistant to *F. oxysporum* race 1
Pea seed borne mosaic virus	
sbm	Resistant to pea seed-borne mosaic virus
Powdery mildew	
er-1	Resistant to *E. polygoni*
wil	Wilts quickly under moisture stress

List of UPOV character, phenotypes and related loci used for varietal grouping in pea is given in **Table 2:** (Vidhi, 2023):

Table 2. List of UPOV character, phenotypes and related loci used for varietal grouping in pea

Character	Descriptor state	Loci
Seed		
1. Shape of starch grain (cotyledonary character)	Round, wrinkled, dimpled	*R. Rb–*
2. Cotyledon colour	Yellow, green, mixed	*I*
	Orange	*Ore*
3. Testa marbling	Brown patterning	*M*
4. Testa anthocyanin	Violet or pink	*F. Fs*
	spots, stripes	*F. Fs*
5. Hilum colour	Cream, black	*Pl*
Plant		
6. Anthocyanin colouration	Purple, red to pink	*A. B. Am*
7. Leaf	Leaflets	*Af*
8. Stipule	Small, rudimentary	*St*
9. Stipule	Rounded apex. pointed	*'Rogue syndrome'*
10. Stipule	Flecked, non-flecked	*Fl*
Pod		
11. Pod well parchment		*P. 1'*
12. Thickened pod wall		*N*
13. Shape at distal end	Blunt, pointed	*Bt*
14. Colour	Yellow	*Gp*
	Blue-green	*Dp*
	Purple	*Pu. Pur*
15. Intensity of green		*Pa. Vim*

The characters associated with domestication are given in Table 3 (Vidhi, 2023).

Table 3. characters associated with domestication

Trait	Wild type	Cultivated	Gene basis
Testa surface	Gritty/rough	Smooth	*Gty*
Testa thickness	Thick	Thin	
Pod dehiscence	Strongly dehiscent	Non-dehiscent	*Dpo*
Seed size (mg)	60-120	80-550	

Genetics of some pea characters are given in **Fig. 5**

Cytology: Pea, *Pisum sativum* L. has 2n = 2x = 14 and all soecies cross to each other with few sterility barriers. All known peas have 14 somatic chromosomes and 7 as the haploid number (Kalloo and Bergh, 1993; Messiaen, *et al.,* 2006). The pea karyotype consists of seven chromosomes, five of which are acrocentric and two submetacentric. Despite its scientific popularity, its relatively large genome size (4.45Gb) made it challenging to sequence compared to other legumes such as *Medicago truncatula* and soybeans. The International Pea Genome Sequencing Consortium was formed to develop the first pea reference genome, and the draft assembly was officially announced in September 2019. It covers 88% of the genome (3.92Gb) and predicted 44,791 gene-coding sequences. The pea used for the assembly was the inbred French cultivar "Caméor" (Wikipedia, 2023).

Genomic Selection: Phenotypic evaluation and efficient utilization of germplasm collections can be time-intensive, laborious, and expensive. However, with the plummeting costs of next-generation sequencing and the addition of genomic selection to the plant breeder's toolbox, we now can more efficiently tap the genetic diversity within large germplasm collections. In this study, we applied and evaluated genomic prediction's potential to a set of 482 pea (*Pisum sativum* L.) accessions—genotyped with 30,600 single nucleotide polymorphic (SNP) markers and phenotyped for seed yield and yield-related components—for enhancing selection of accessions from the USDA Pea Germplasm Collection. Genomic prediction models and several factors affecting predictive ability were evaluated in a series of cross-validation schemes across complex traits. Different genomic prediction models gave similar results, with predictive ability across traits ranging from 0.23 to 0.60, with no model working best across all traits. Increasing the training population size improved the predictive ability of most traits, including seed yield. Predictive abilities increased and reached a plateau with increasing number of markers presumably due to extensive linkage disequilibrium in the pea genome. Accounting for population structure effects did not significantly boost predictive ability, but we observed a slight improvement in seed yield. By applying the best genomic prediction model (*e.g.,* RR-BLUP), we then examined the distribution of genotyped but nonphenotyped accessions and the reliability of genomic estimated breeding values (GEBV). The distribution of GEBV suggested that none of the nonphenotyped accessions were expected to perform outside the range of the phenotyped accessions. Desirable breeding values with higher reliability can be used to identify and screen favorable germplasm accessions. Expanding the training set and incorporating additional orthogonal information (*e.g.,* transcriptomics, metabolomics, physiological traits, etc.) into the genomic prediction framework can enhance prediction accuracy (Bari *et al*., 2021).

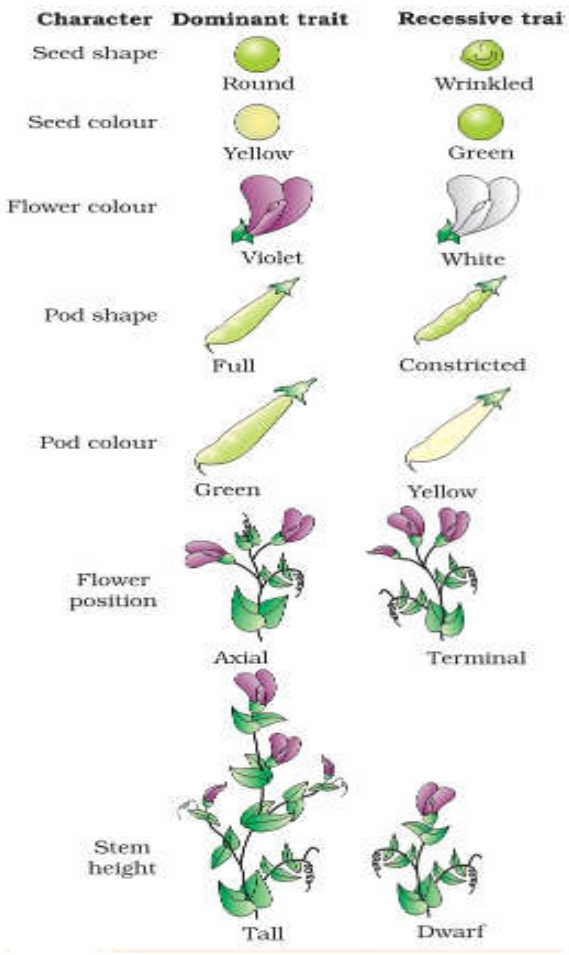


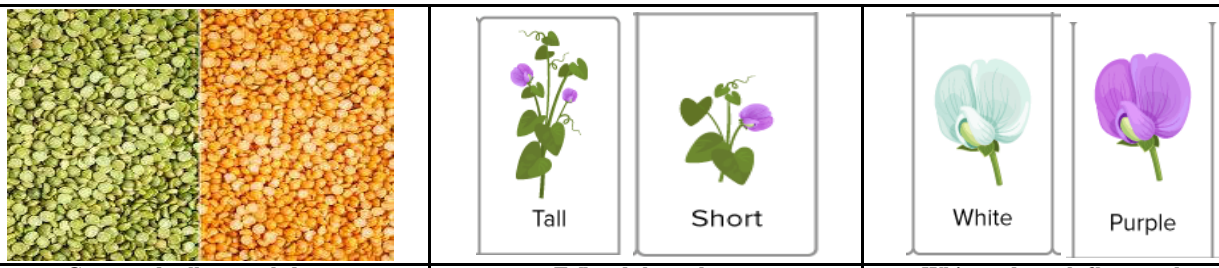
Fig.5 : Genetics of pea characteristics

GENETIC DIVERSITY

Peas also have several visible characteristics that may vary. These characteristics include seed form and color, flower color, pod form and color, placement of pods and flowers on stems, stem length and others. Each characteristic has two common values. For example, seed form may be round or wrinkled, and flower color may be white or purple (violet). For some of the characters see the Fig. 6 (Myers and Graham, 2001).

		
Normal leaves	**Semi-leafless**	**Leaflets and tendrils**
		
Pod apex shape: blunt pod apices, and pointed apices	**Pods: Stringed and stringless**	**Seed Shape: Wrinkled and round (dimpled) seeds**

Continue …..



Green and yellow cotyledons	Tall and short plants	White and purple flower color

Fig. 6: Several visible characteristics of pea

Market classes of field pea varieties developed by the AAFC field pea breeding program has reported A-Mellow, B-Green, C and D-Mapple, E-Marrowfat, F-Red (Fig. 7) (MPG, 2023.)

Fig.7. Market classes of field pea varieties developed by the AAFC field pea breeding program. A-Mellow, B-Green, C and D-Mapple, E-Marrowfat, F-Red (MPG, 2023.)

Simple sequence repeat (SSR) markers, morphological traits and pedigree data were used to analyse genetic diversity of European pea (*Pisum sativum* L.) germplasm, to determine differences between *P. sativum* var. *arvense* and *P. sativum* ssp. *sativum* groups, and to estimate genetic variability among and within eighteen *P. sativum* accessions. Coancestry coefficients across investigated accessions varied from 0.46 to 1.00. The average dissimilarity index between *Pisum sativum* var. *arvense* and *P. sativum* ssp. *sativum* groups was 0.99, where estimates obtained by pedigree data might be overestimated. Average morphological distance among all accessions was slightly higher than average molecular distance (0.62 and 0.59, respectively). Average morphological distance between *P. sativum* ssp. *sativum* and *P. sativum* var. arvense groups was also higher than average molecular distance (0.71 and 0.69, respectively). Results, according to morphological traits used in this study were well suited to assess differences among accessions. Accessions were grouped according to their botanical characters and agronomic use. Genetic distances estimated by molecular marker (SSR) data in comparison with distances estimated by conventional methods (pedigree and morphologic traits) showed higher similarity with genetic distances estimated by morphological data. Results indicated that intercrosses between *arvense* and *sativum* accessions as well as inclusion of valuable landraces into breeding programmes might prevent loss of diversity in the *Pisum* gene pool (Cupic *et al*., 2009). A total of 122 accessions of different wild and cultivated *Pisum* sp. were analysed using retrotransposon-based insertion polymorphisms (RBIP) markers. The *Pisum* materials included wild and cultivated (landraces and cultivars) materials from the World core collection of the John Innes Centre (JI) representing all generally recognized *Pisum* taxa, landraces materials from the Spanish core collection, and commercial pea cultivars largely sown in Spain. The overall polymorphism detected by RBIP marker was high and all accessions, except two pairs, could be distinguished by their marker pattern. Principal component and phylogenetic analyses clearly discriminated *P. fulvum* and *P. abyssinicum* samples from both each other and *P. sativum*, while *P. elatius* and *P humile* samples were scattered among the other taxa clusters, supporting the existence of three well defined taxa in the genus *Pisum* (*P abyssinicum*, *P. fulvum* and *P. sativum*). These results also suggest that the Spanish pea core collection of landraces maintains a relatively high variability which is only partially represented in cultivars generally sown in Spain. Thus, Spanish landraces are still a source of genetic variability for breeding new pea cultivars (Martin-Sanz *et al*., 2011).

The genetic diversity among 28 pea (*Pisum sativum* L.) genotypes was analyzed using 32 simple sequence repeat markers. A total of 44 polymorphic bands, with an average of 2.1 bands per primer, were obtained. The polymorphism information content ranged from 0.657 to 0.309 with an average of 0.493. The variation in genetic diversity among these cultivars ranged from 0.11 to 0.73. Cluster analysis based on Jaccard's similarity coefficient using the unweighted pair-group method with arithmetic mean (UPGMA) revealed 2 distinct clusters, I and II, comprising 6 and22 genotypes, respectively. Cluster II was further differentiated into 2 subclusters, IIA and IIB, with 12 and 10 genotypes, respectively. Principal component (PC) analysis revealed results similar to those of UPGMA. The first, second, and third PCs contributed 21.6, 16.1, and 14.0% of the variation, respectively; cumulative variation of the first 3 PCs was 51.7% (Kumari *et al.,* 2013). A total of 34 pea (*Pisum sativum* L.) genotypes including 7 adapted varieties, 6 popular local cultivars and 21 advanced breeding lines developed through crossing of elite cultivars were evaluated for genetic diversity and relatedness with 16 morphological traits and 15 SSR markers. Genotypes viz., DDR-23, E-6, Makuchabi and KPMR-885 were identified as early flowering while Rachna, IPFD 09-2, CAU FP-1, IPFD 1-10 and Pant P-136 were identified as high yielding. The number of alleles per SSR marker varied from 2 to 5 per locus. Polymorphic information content values (PIC) ranged from 0.105 to 0.560 per locus. Variability among groups (FIS=0.938) and variability within individuals (FIT=0.948) was low. The minimum and maximum molecular genetic distances were found to be 0.12 (Pant P-136 with VL-51) and 0.78 (E-6 with LP-4) respectively. Genotypes IPFD 09-2, HFP-620, Azad P-1, Matek, IPFD 1-10, CAU FP-1, IPFD 09-3, Pant P-136, Rachna, E-6, Matek and LP-3 showed high level of genetic diversity. Pea improvement through hybridization by utilizing diverse genotypes is suggested for breeding suitable genotypes for North Eastern region (Handerson et al., 2014). Eleven novel genic markers were developed from Field pea expressed sequence tag (EST) sequences having significant similarity with gene calls from *Medicago truncatula* spanning at least one intron. In this study, 96 cultivars widely grown or used in breeding programs in the USA and Canada were analyzed for genetic diversity using 31 microsatellite or simple sequence repeat (SSR) and 11

novel EST-derived genic markers. The polymorphic information content varied from 0.01-0.56 among SSR markers and 0.04-0.43 among genic markers. The results showed that SSR and EST-derived genic markers displayed one or more highly reproducible, multi-allelic, and easy to score loci ranging from 200 to 700 bp in size. Genetic diversity was assessed through unweighted neighbor-joining method, and 96 varieties were grouped into three main clusters based on the dissimilarity matrix. Four subpopulations were determined through STRUCTURE analysis with no significant geographic separation of the subpopulations. The findings of the present study can be used to select diverse genotypes to be used as parents of crosses aimed for breeding improved pea cultivars (Jain *et al*., 2014). During a national Swedish collection mission of vegetable varieties conserved 'on farm' more than 70 pea accessions were obtained, many of which had been grown locally for more than 100 years. In spite of a likely origin in the multitude of obsolete commercial pea varieties available on the Swedish seed market in the 19th century, the rediscovered local cultivars have lost their original names and cultivar identity while being maintained 'on farm'. To analyze genetic diversity in the repatriated material 20 accessions were genotyped with twelve SSR markers and compared with 15 obsolete cultivars kept in genebanks and 13 cultivars preserved as non-viable seeds collected in 1877-1918. Most of the local cultivars were genetically distinct from each other, and in only a few cases could a possible origin in a tested obsolete cultivar be suggested. These results reflect the wide diversity of pea cultivars present in Sweden during the 19th century. Both between and within accession genetic diversity was larger among the historical samples of obsolete cultivars compared to local cultivars and cultivars preserved in genebanks, indicating genetic erosion over time both in genebanks and during conservation 'on farm' (Hagenblad *et al.,* 2014).

Field pea (*Pisum sativum* L.) is an important protein-rich pulse crop produced globally. Increasing the lipid content of *Pisum* seeds through conventional and contemporary molecular breeding tools may bring added value to the crop. However, knowledge about genetic diversity and lipid content in field pea is limited. An understanding of genetic diversity and population structure in diverse germplasm is important and a prerequisite for genetic dissection of complex characteristics and marker-trait associations. Fifty polymorphic microsatellite markers detecting a total of 207 alleles were used to obtain information on genetic diversity, population structure and marker-trait associations. Cluster analysis was performed using UPGMA to construct a dendrogram from a pairwise similarity matrix. Pea genotypes were divided into five major clusters. A model-based population structure analysis divided the pea accessions into four groups. Percentage lipid content in 35 diverse pea accessions was used to find potential associations with the SSR markers. Markers AD73, D21, and AA5 were significantly associated with lipid content using a mixed linear model (MLM) taking population structure (Q) and relative kinship (*K*) into account. The results of this preliminary study suggested that the population could be used for marker-trait association mapping studies (Ahmad et al., 2015). In order to assist pea development efforts, we assembled the USDA Pea Single Plant Plus Collection (PSPPC), which contains 431 *P. sativum* accessions with morphological, geographic and taxonomic diversity. The collection was characterized genetically in order to maximize its value for trait mapping and genomics-assisted breeding. To that end, we used genotyping-by-sequencing—a cost-effective method for *de novo* single-nucleotide polymorphism (SNP) marker discovery—to generate 66 591 high-quality SNPs. These data facilitated the identification of accessions divergent from mainstream breeding germplasm that could serve as sources of novel, favorable alleles. In particular, a group of accessions from Central Asia appear nearly as diverse as a sister species, *P. fulvum,* and subspecies, *P. sativum* subsp. *elatius*. PSPPC genotypes can be paired with new and existing phenotype data for trait mapping; as proof-of-concept, we localized Mendel's *A* gene controlling flower color to its known position. We also used SNP data to define a smaller core collection of 108 accessions with similar levels of genetic diversity as the entire PSPPC, resulting in a smaller germplasm set for research screening and evaluation under limited resources. Taken together, the results presented in this study along with the release of a publicly available SNP data set comprise a valuable resource for supporting worldwide pea genetic improvement efforts (Holdsworth *et al.,* 2017). We studied genetic structure, diversity and inter-relationships in a worldwide collection of 151 pea accessions using 21 morphological descriptors and 20 simple sequence repeat (SSR) primers. Among quantitative traits, seed yield per plant followed by seed weight and pod length have shown significant variation. SSR primers showed a high level of diversity and amplified a total of 179 alleles with an average of 8.95 alleles per primer in a size range of 95–510 bp. Primer AA-122 amplified the maximum (21) alleles while primer AB-64 amplified the minimum (4) alleles. Mean polymorphism information content (PIC) was 0.72. Observed heterozygosity (H_o) varied from 0.10 to 0.99 in primers AB-64 and AD-160, respectively, with a mean value of 0.46. Expected heterozygosity (H_e) ranged from 0.47 to 0.94 in primers C-20 and AA-122, with a mean of 0.75. Genetic relationships inferred from a neighbour-joining tree separated accessions into 3 groups. Bayesian model-based STRUCTURE analysis detected 3 gene pools for the analysed pea germplasm and showed a high admixture within individual accessions. Furthermore, STRUCTURE analysis showed that these 3 gene pools co-existed in accessions belonging to different geographic regions indicating frequent transference and exchange of pea germplasm during its domestication history. The results of the present study will be useful in understanding the pea's genetic structure and in the selection of suitable diverse accessions for future improvement programmes in the pea (Rana *et al*., 2017).

The field pea is very important when it comes to the nutrition of domestic animals, due to a high content of proteins in its grains and above ground biomass. The aim of this study was to examine genetic variability in quantitative traits of newly created field pea hybrids. The researchers studied two cultivars, one line and their F_3 and F_4 hybrids. The following quantitative traits were analysed: number of pods per plant, number of grains per pod, 1000 seed weight and grain yield. The largest number of pods per plant was recorded for the Baccara × L-CC line hybrid, with a statistically significantly larger ($P < 0.01$) number of pods per plant than all the other investigated genotypes, lines and hybrids. L-CC line × Baccara, and Saša × L-CC line had a significantly larger ($P < 0.05$) number of grains per pod. The smallest number of grains per pod was recorded for the Saša and Baccara × Saša hybrid. The genotype vs. year interaction had a significant ($P < 0.05$) influence on 1000 seed weight. Significantly higher ($P < 0.05$) 1000 seed weight was recorded for the Baccara genotype, when compared with all other investigated genotypes, lines and hybrids. The lowest 1000 seed weight was recorded for the L-CC line. The genotype × year interaction had a significant influence on the seed yield of field pea. During this research, high seed yields were achieved by the Baccara genotype and Baccara × L-CC line and Baccara × Saša hybrids (Lakić et al., 2019). Forty seven garden pea genotypes were characterized using thirty four pea specific microsatellite markers. Mean square values were highly significant for all the characters. Nearly 75% of the total variation was contributed by 3 traits *viz*. green pod yield per plant (43.18), plant height (20.91) and number of nodes per plant (10.27). 28 polymorphic SSR markers were used. Average PIC value was 0.55. NTSYS clustering based on UPGMA grouped the genotypes into two major groups I and II (dwarf and tall, respectively). The larger group consisted of 43 genotypes (subgroups I-VII) and smaller group had 3 genotypes (subgroup VIII). One genotype (PMR-19) separated from other genotypes. The dendrogram depicted overall similarity coefficient ranged from 0.59 to 0.89. The lowest genetic similarity (0.39) was observed between major group I and major group II. Maximum genetic similarity (0.89) was found between two pairs i.e. PB-89 and C-96 (first pair) and Angoori and GS-10 (second pair). Neighbor joining tree thus obtained highly corresponds to the clustering observed using NTSYS indicating that the analysis was reliable. The findings of the present study can be used to select diverse genotypes to be used as parents of crosses aimed for breeding improved pea cultivars (Singh et al., 2021). A total of fifty-seven pea (*Pisum sativum* L.) genotypes including 50 accessions and seven varieties were evaluated for the nine quantitative traits to assess the variability and association patterns for the characters under study. All the studied parameters showed significant ($p \leq 0.01$) differences, indicating the presence of sufficient variability among the genotypes. Minimum days to first picking were observed for Leena Pak and Meteor each variety taking 61.67 days to first picking. Highest number of pods

plant-1 (37.67), hundred green seeds weight (57.33 g) and green pod yield (10.19 tons) was recorded for genotype UAP-47. Maximum pod length (9.87 cm), seeds pod-1 (9.33) and hundred green pods weight (583.00 g) was recorded for variety Green Gold. However, minimum pods plant-1 (15.00) was recorded for pea variety Rizwaan. The lowest pod length (3.57 cm) was displayed by genotype UAP-13. However, minimum number of seeds pod-1(4.00) was recorded for genotype UAP-39. The genotype UAP-30 displayed minimum hundred green pods weight (224.33 g) while the lowest green pod yield (4.11 tons) was recorded for pea variety Meteor. Plant height, pods plant-1, pod length, hundred green seeds weight and hundred green pods weight were the major traits contributing to green pod yield as these characters displayed significantly positive correlation with green pod yield. Principal Component Analysis (PCA) revealed that the first five principal components had Eigen values > 1 accounting for 78.9 % of total variation. The first principal component was characterized by pods plant-1, green pod yield, plant height and hundred green seeds weight. The second principal component was dominated by pod length, hundred green pods weight, seeds pod-1, hundred green seeds weight and days to first picking. Cluster analysis for quantitative traits grouped pea genotypes into five different clusters at a dissimilarity level of 0.61 which also depicted the presence of high magnitude of variation among the studied genotypes. On the basis of superior performance for maturity, yield and yield-related traits, pea genotypes Leena Pak, UAP-47, UAP-29 and Green Gold are recommended for testing across locations and for onward use in pea breeding programs (Aman *et al*., 2021).

The objective of this study was to scrutinizes the genetic diversity using twenty-eight genotypes (Parents + Hybrids) with the help of 12 agro-morphological traits and 18 useful SSR markers. The study carried out with 28 genetically diverse pea genotypes (7 parents and 21 F1 crosses, developed in half diallel fashion) with recommended agro-practices and evaluation were done under Randomized Block Design (RBD). The data observed were analyzed by SPAR.2.0 software. It was found that parentage and crosses have genetic variability (among parentage and F1s) for all the agro-morphological traits. The extent of lowest and highest PCV and GCV was recorded for days to maturity and seed yield per plant respectively. Broad –sense heritability magnitude ranged from 28.17% for number of seeds/pod to 76.31% for Plant height. Along with high genetic advance (>20%) highest heritability (>60%) coupled and was assessed for number seeds/pod (76.31% to 26.35%). The No. of pod per plant (r = 0.685 and 0.670, respectively at P≤0.01) has substantial genotypic and phenotypic correlation with seed yield/plant followed by pod length (0.639), number of nodes to first flowering (0.576) etc. Using molecular data measured genetic coefficients revealed varying degree of genetic relatedness among the 7 parental lines of field pea and 0.12 to 0.89 range Jaccard's similarity coefficient has been reported. On the basis of 18 SSR markers study 7 parental lines of field pea can be differentiated into two major groups, where with highest Jaccard's similarity coefficient (0.89) Prakash consisted in group 1 (Kumar *et al.,* 2022). Genetic diversity among 56 garden pea genotypes was assessed using 12 morphological descriptors, 19 quantitative traits and 8 simple sequence repeat (SSR) markers. Eight morphological descriptors were found polymorphic, and highest Shannon diversity index was recorded for pod curvature (1.18). Mahalanobis D^2 illustrating genetic divergence arranged 56 genotypes into six clusters, with the highest inter-cluster distance between clusters IV and VI (18.09). The average values of Na (number of alleles), Ne (effective number of alleles), I (Shannon's Information index), PIC (polymorphism information content), Ho (observed heterozygosity) and He (expected heterozygosity) were 3.13, 1.85, 0.71, 0.36, 0.002 and 0.41, respectively. Pair wise genetic distance among all pairs of the genotypes varied from 0.33 to 1.00 with an average of 0.76. Based on genetic distance, the genotypes were classified into two main clusters (A and B) by cluster analysis, whereas structure analysis divided the genotypes into four sub-populations. The SSR makers indicated that present of genetic variability among the studied genotypes. When, we compared the groups formed by agro-morphological and molecular data, no genotypes were observed, indicating that both stages of characterization are crucial for a better understanding of the genetic variability. Hybridization between genetically diverse genotypes can be exploited to expend the genetic variability and introduce new traits in the pea breeding program (Sharma *et al*., 2022).

A collection of 46 pea (*Pisum sativum* L.) accessions, mostly from Europe, were analysed for genetic diversity using the GenoPea 13.2 K SNP Array chip. Of these accessions were 24 nomal-leaved and 22 semi-leafless. Principal components analysis (PCA) separated the peas into two groups character- ized by the two different leaf types, although some genotypes were exceptions and appeared in the oppo-site group. Cluster analysis confirmed the two groups.A dendrogram showed larger genetic distances between genotypes in the normal-leafed group com- pared to semi-leafless genotypes. Both PCA and cluster analysis show that the two leave types are genetically divergent. So normal-leaved peas are an interesting genetic resource, even if the breeding goal is to develop semi-leafless varieties (Tran et al., 2023). A collection of 46 pea (*Pisum sativum* L.) accessions, mostly from Europe, were analysed for genetic diversity using the GenoPea 13.2 K SNP Array chip. Of these accessions were 24 nomal-leaved and 22 semi-leafless. Principal components analysis (PCA) separated the peas into two groups characterized by the two different leaf types, although some genotypes were exceptions and appeared in the opposite group. Cluster analysis confirmed the two groups. A dendrogram showed larger genetic distances between genotypes in the normal-leafed group compared to semi-leafless genotypes. Both PCA and cluster analysis show that the two leave types are genetically divergent. So normal-leaved peas are an interesting genetic resource, even if the breeding goal is to develop semi-leafless varieties (Tran et al., 2023). To determine the amount of diversity in pea breeding materials with the objective to classify a set of potential parents carrying novel/economic variations that could be used in future breeding of pea varieties. A total of 45 pea accessions were analysed for phenotypic and molecular diversity using 17 agro-morphological traits and 52 SSR markers. All traits under investigation showed considerable genetic variation. The genotypes exhibited 6.7, 2.7 and 12-fold variation for traits viz., pods/plant, 10-pod weight and yield/plant, respectively. Among 52 SSR markers, 22 were found to be polymorphic. A total of 90 allelic variants were detected, with an average of 2.7 alleles/locus. PIC and D-values for markers AA135 (0.79 and 0.81) and PSMPSAD51 (0.7 and 0.74) were the highest, while AB40 (0.19 and 0.2) had the lowest. Two principal components PC1 and PC2 explained 46.96 and 23.96% of total variation, respectively. The clustering based on agro-morphological traits differentiated 45 individuals into three mega clusters, while SSR markers-based clustering classified these accessions into four groups. Based on their uniqueness, we identified a set of genotypes (VRPD-2, VRPD-3, PC-531, 'Kashi Nandini', 'Kashi Udai', 'Kashi Mukti', 'Arkel', VRPE-101, 'Azad Pea-3', EC865944, VRPM-901 and VRP-500) harbouring genes for various economic traits. The findings presented here will be extremely useful to breeders who are working on improvement of peas through selective introgression breeding (Devij *et al.,* 2023).

BREEDING

Genetic resources: A large genetic diversity has been found in *Pisum sativum* collections from both Africa (*e.g.* Ethiopia) and Asia (*e.g.* India). Genetic erosion in field pea is probably less than in cereals, because of less progress in cultivar development and hence less replacement of landraces by a few new cultivars. Many germplasm collections of pea are held all over the world. The world collection of cultivars and mutant forms of *Pisum sativum* is housed at the Nordic Gene Bank, Alnarp, Sweden (about 2700 accessions). Emphasis in the collection is on lines with multiple disease resistance, wild and primitive types, lines carrying structural mutations, breeding lines and cultivars of special interest. Large *Pisum sativum* collections are held in Australia (Australian Temperate Field Crops Collection, Horsham, Victoria, 6300 accessions), the Russian Federation (N.I. Vavilov All-Russian Scientific Research Institute of Plant Industry, St. Petersburg, 6200 accessions), Italy (CNR - Istituto di Genetica Vegetale, Bari, 4100 accessions), the United States (Western Regional Plant Introduction Station, Pullman, 3500 accessions;

Horticultural Sciences Department, NY State Agricultural Experiment Station, Geneva, 2500 accessions), China (Institute of Crop Germplasm Resources (CAAS), Beijing, 3400 accessions), and the United Kingdom (John Innes Centre, Department of Applied Genetics, Norwich, 2700 accessions). The largest collection of *Pisum sativum* germplasm in Africa is located at the Institute of Biodiversity Conservation, Addis Ababa, Ethiopia, with over 1600 accessions (Messiaen *et al*., 2006).

A large number of ex-situ germplasm collections have been reported around the world in public domain and given in Table **3** (Vidhi, 2023).

Table 3. Germplasm resources of peas at major Centres

FAO Inst. Code	Country	No. of accessions
AFTC	Australia	6567
SAD	Bulgaria	2787
ICAR-CAAS	China	3837
GAT	Germany	5336
BAR	Italy	4297
CGN	Netherlands	1008
WTD	Poland	2899
VIR	Russia	6790
ICARDA	Syria	6105
NGB	Sweden	2724
JTC	UK	3194
USDA	USA	3710

In India, about 2000 pea germplasm accessions are conserved at NBGPGR, New Delhi, IIVR, Varanasi and IIPR, Kanpur, Besides, a few state agricultural universities rich in vegetable pea germplasm are G.B. Pant University of Agric. and Technology, Pantnagar, Punjab Agricultural University, Ludhiana, Haryana Agriculture University, Hisar, JNKVV, Jabalpur and Indian Agric.Res. Inst., New Delhi (Vidhi, 2023).

Breeding Goals: The breeding goals for pea are 1) High green pod yield, 2) Long, attractive green pods with more seeds/pod (9-12 seeds), 3) Sweetness , 4) High shelling percentage, 5) Specific maturity (early, mid), 6) Suitable for freezing and canning and 7) Resistant/tolerant to frost (Vidhi, 2023).

Crop Improvement: Manipulation of morphological traits has resulted in determinate types with even maturity, suitable for mechanization and semi-leafless types with reduced lodging. A peculiar mutant character, 'Afila', with tendrils in the place of leaflets has been introduced in commercial dwarf field pea cultivars. A consensus genetic linkage map has been developed for *Pisum sativum* based on various linkage maps. Quantitative trait loci associated with, among others, seed yield, seed protein concentration, early maturity, lodging resistance, plant height and resistance to various biotic stresses (including Ascochyta blight, Aphanomyces root rot and *Orobanche crenata*) have been identified. Procedures for direct as well as indirect, callus-mediated somatic embryogenesis of pea have been developed for breeding purposes. Transgenic plants have been produced using *Agrobacterium* -based transformation vectors, *e.g.* to increase resistance to *Callosobruchus chinensis*, *Callosobruchus maculatus* and *Bruchus pisorum* by incorporating α -amylase-inhibiting capacity from *Phaseolus vulgaris* (Messiaen *et al.,* 2006).

Breeding Methods: Breeding Methods *viz*., Selection, Single seed decent method of selection, Pedigree selection, Bulk method of selection, Recurrent selection, Hybridization, Back crossing, Line breeding, have been adopted for pea improvement (CH, 2017).

Breeding Procedures: Peas are self-pollinated due to cleistogamy and accordingly, the common breeding procedures applicable to self-pollinated crops viz. pedigree, bulk, single seed descent (SSD), back-cross and mutation breeding are used in pea breeding. Single seed descent method is now becoming common in peas. This is particularly, useful in those situations where selected better lines are intercrossed. F_1 plants are grown to produce 500 or more F_2 seeds. One seed is harvested from each F_2 plant and the harvested seeds are bulked to plant F_3. This procedure continues till F_5 in which phenotypically, superior individual plants are selected for future plant to progeny planting and evaluation. A major advantage of this method is, that, it can be carried out with less resources and the rapid advancement of generations is possible in field and glass-house/off season-nursery. While advancing the generations, selection for highly heritable traits is practiced frequently in early generations, before lines are grown out as small plots in F_4/F_5 generation. Shuttle breeding is also practised in peas where alternate generations (like F_3 and F_5) are grown at off-site locations. For example, in India alternate generations can be grown in late kharif in Pune and Nasik in Maharashtra and followed by winter season in northern plains. In this way, 2 generations can be grown in a year. There is widespread use of SSD utilizing glasshouses or plant growth chambers to speed-up early generations while also maintaining a wider level of variability between lines before growing plant to progeny rows for field evaluation and selection. Bulk selection is also used by some breeders. In garden pea number of green pods/plant, green pod weight, pod length and number of seeds/pod have been shown to be the major yield components affecting the green pod yield. These yield components usually do not show component compensation effect and therefore, simultaneous improvement for these characters should be possible. A dose of 10-15 krad of gamma rays is appropriate for seeds. A good criterion of effectiveness of any mutagen is germination reduction, not exceeding 50% for gamma radiation, better only 30% for neutrons and certain chemical mutagens. Stronger germination reduction may result for a high number of chromosomal aberrations and this in turn will lead to high sterility. Among chemicals, EMS, NEU, EI, NMU and sodium azide seem to be the most efficient mutagens for peas (Vidhi, 2023).

Breeding for semi-leafless genotype: The pea (*Pisum sativum* L.) is an excellent protein source for livestock and human nutrition. However, its growth is hampered by several factors including powdery mildew (*Erysiphe pisi* DC) and lodging in irrigation areas. These limitations may be solved through combining a Canada powdery mildew-resistant pea (**Mp1807**) with green cotyledon cultivar (**Graf**) by means of sexual hybridization. A bred semi-leafless pea, cultivar Longwan No. 6, was selected and evaluated in multiple ecological zones to investigate and evaluate high-yield, adaptability, and resistance to root rot (*Aphanomyces euteiches* Drechs. f. sp. *pisi*) and powdery mildew from 2012 to 2014. The results revealed that Longwan No. 6 was characterized by lodging resistance and moderate powdery mildew resistance. Longwan No. 6 is a

semi-leafless pea with limited pods. It has semi-dwarf stems and an erect growth pattern. The height of Longwan No. 6 ranges from 51.7 to 69.1 cm. Its main stem has 12.3–16.5 nodes with the first flower nodes at the 9th node. The flowering period of Longwan No. 6 is about 18–23 days. The seeds are smooth and round in shape and have clear coats, good color, faint yellow cotyledons, and yellowish-white hilum. The stipules are rabbit-ear-shaped, the leaf surface has fewer denudation spots, and there is no cyanotic spot in the leaf axils. The pods are straight, blunt, and green and not easy to split. The fresh stems and pods are green. Each plant has 16.0–18.6 pods, with a double-pod rate of 40.0–75.0%. The pods are concentrated, the maturity is consistent, and the seeds bulge quickly. The number of flowers per inflorescence is 1 to 2. The pod length of the plant is 5.6–6.5 cm, the number of pods is 3.5–4.4, and the pod splitting rate is 20.0%. The number of grains per plant is 21 to 65, and the yield per plant is 5.0 to 12.5 g. One hundred grain weight (100-grain) is 22.1–28.8 g, and the seed coat rupture rate is 1%. Thus, adopting the Longwan No. 6 pea cultivar will contribute to improvements in pea production in arid irrigation and rain-fed areas and other similar ecological conditions (Fig. 8) **(**Yang *et al.,* 2022**).**

Female parent (Mp1807) (powdery mildew-resistant)

Maleparent (Graf). (green cotyledon cultivar)

Longwan No. 6- Plant selected and evaluated for F7 generations. (semi-leafless pea, cultivar; lodging resistance and moderate powdery mildew resistance; semi-leafless pea with limited pods.)

Longwan No. 6- Flower

Longwan No. 6- Green pods

Longwan No. 6- Dry Seeds

Fig.8. Development of semi-leafless pea cultivar Longwan No. 6

Vegetable Pea Early variety (Kamini, 2009):

The early varieties are more popular in India because of better economic return. They are not high yielders but give high initial remuneration to the growers. Two pickings of green pods are generally done in these varieties, the first being after 60 days of sowing and second after 15-20 days of first picking. The maturity period is 60-80 days.

1. ***Asauji*:** A dwarf, green and smooth seeded variety developed at IARI by selection made from the genetic material collected from Amritsar. Pods are produced singly; flowering in 30-35 days after sowing and blossom appear in 6-7 node. Pods are about 8 cm long, curved, dark green, narrow and appear round when fully developed, seven seeded and giving high shelling percentage (45%).

2. ***Early Superb:*** An introduced and dwarf variety from England with yellowish green foliage. It flowers in about 45 days and first blossom appears at 8-10th node. Pods are borne singly; these are dark green, curved with 6-7 smooth seeds. It gives high shelling percentage (40%).

3. ***Meteor*:** An introduced variety from England. Plants are 35-40 cm tall, dark green, pods are produce singly, dark green, 8.7 cm long with seven smooth seeds. It gives high shelling percentage (45%).

4. ***Arkel:*** This widely grown variety is, an exotic variety from France. The plant is dwarf but the growth is vigorous and may grow upto 45 cm. Flowers are white and are borne in double on few lower nodes and single afterwards. It flowers in 35-40 days from the sixth node onwards. Pods are dark green, 8.5 cm long, incurved towards the sutures and pointed distal end with 8-10 well filled, wrinkled seeds. It gives high shelling percentage (40%). It is suitable for both fresh market and dehydration. It takes 50-55 days for first picking. Green pod yield 4-5 t/ha. This variety is highly susceptible to powdery mildew.

5. ***Early Badger*:** A dwarf, wrinkled seeded variety introduced from USA. Pods are ready for picking in 60-65 days after sowing. First blossom appears in 10-11th node; pods are yellowish green and borne singly, 7.5 cm long with 5-6 bold and sweet seeds. It is a good caning variety and resistant to *Fusarium* wilt.

6. ***Little Marvel*:** A dwarf, wrinkled seeded variety introduced from England. It is bred in England from the cross Chelsea Gem x Suttons Alaska. Foliage dark green; first blossom appears at 9-10th node in 40 days after sowing. Pods are 8 cm long, borne singly, thick, shinny, dark green, straight and broad containing 5-6 very sweet seeds.

7. ***Alaska:*** An introduced variety from England. Pods are light green and appears singly with 5-6 small, bluish-green seeds.

8. ***VL-Ageti Matar-7 (VL-7):*** Developed at Almora through advanced generation selection from the cross Pant Uphar x Arkel. Plants are dwarf with dark green foliage and white flowers. Pods are light green, attractive, slightly incurved towards sutures at the distal end and medium in size (about 8 cm) containing 6-7 seeds. The seeds are light green, dimpled bold and very sweet with high TSS (16.8%). Average yield 10 t/ha with 42% shelling.

9. ***Jawahar Matar 3 (JM 3, Early December):*** This variety was developed at Jabalpur through hybridization of T19 x Early Badger followed by selections. Plant height 70-75 cm with bushy growth habit; flower colour white, pods light green, roundish-oval in shape with 4-5 wrinkled seeds. It gives high shelling percentage (45%). This variety suffers severely from powdery mildew. First picking starts at 50-55 days after sowing. Average yield 4 t/ha.

10. ***Jawahar Matar 4 (JM 4):*** This variety was developed at Jabalpur through advanced generation selections from the cross T19 x Little Marvel. Plant height 65 cm, foliage and stem green. First picking can be taken after 70 days. Pods are green, medium in size (7 cm) with 6-7 green, wrinkled and sweet seeds. It is highly susceptible to powdery mildew. Average pod yield 7 t/ha with 40% shelling.

11. ***Harbhajan (EC 33866):*** Developed at Jabalpur by selection from the exotic genetic stock. It is very early and first picking can be taken in 45 days of sowing. Plant type resembles that of field peas; pods are small with yellow, round and small seeds. It is also highly susceptible to powdery mildew disease. Average pod yield 3 t/ha.

12. ***Pant Matar 2 (PM-2):*** It was developed at Pantnagar through pedigree selection from the cross Early Badger × IP3 (Pant Uphar). Plant height 50-55 cm; fruit setting starts from 6th node. Pods are green, relatively small in size with 6 sweet and wrinkled seeds. First picking starts 55 days after sowing. It is also highly susceptible to powdery mildew. Average pod yield 7-8 t/ha.

13. ***Jawahar Peas 54 (JP 54):*** This powdery mildew resistant variety was developed at Jabalpur through advanced generation selection from a double cross (Arkel × JM5) × ('4bc' × JP 501). Plants are dwarf (45-50 cm) and vigorous, pods are big, incurred towards sutures (sickle shaped) and enclosing 8-9 big, wirnkled, greenish-yellow seeds. Average pod yield 7 t/ha.

14. ***Matter Ageta 6*:** Dwarf, high yielding variety developed at Ludhinana through pedigree selction from the cross Massey Gem × Harabona. Plants are dwarf (40 cm), erect, vigorous and quick growing; foliage green and 1-2 pods are borne in a bunch; first picking within 43-45 days after sowing; pods are long with 6 seeds; it is tolerant to high temperature; average pod yield 6 t/ha with 44% shelling.

15. ***Hisar Harit (PH1):*** This mid-early variety was developed at Hisar through bulk-pedigree method of selection from the cross Bonneville × P23. Plant semi dwarf, first picking after 60 days, foliage green; single to double podded; pod well filled and sickle shaped, large and green; seed green dimpled after drying. Average pod yield 9 t/ha.

16. ***Jawahar Peas-4*:** This powdery mildew resistant and wilt tolerant variety for hillocks was developed at Jabalpur through advanced generation selections from a triple cross Local Yellow Batri × (6588 × 46C). Plants attain height of around 75 to 80 cm on hillocks and about 1 m in plants; medium size pods with 5-6 big, green seeds. First picking after 60 days in hillocks and 70 days I plains. Average pod yield 3-4 t/ha in hillocks and 9 t/ha in plains.

Other improved varieties developed were Harabora from Ludhiana, Pant Sabji Matar 3 from Pantnagar.

Vegetable Pea Midseason varieties (Kamini, 2009; IIHR, 2023):

These are high yielding varieties capable of giving 3 pickings. The first picking can be done 90 days after sowing and the subsequent two at an interval of 15 days.

1. ***Bonneville:*** It is an introduced variety from USA recommended for cultivation by IARI. It is a popular variety. Plant medium tall (60 cm), flowers are mostly borne in doubles; pods are light green, straight, big (9 cm) with 6-7 well-filled, sweet, bold and wrinkled seeds. It takes 65-70 days for first flowering and it appears in 13-15 th node. It is susceptible to powdery mildew disease. Average pod yield 9 t/ha with 45% shelling.

2. ***Alderman*:** It is an introduced variety from USA. Plants are tall (150 cm); pods are more or less straight, big (9-10 cm)

and borne singly with 8-10 very sweet, shiny seeds. It is an excellent cultivar for freezing purpose.

3. ***Perfection New Line*:** It is an introduced variety from USA. The plant is vigorous and medium tall and flowers are borne in doubles; pods are about 8 cm long, dark green with 6-7 light green, sweet and wrinkled seeds. First picking starts after 85 days. It is a heavy yielding variety. Average pod yield 10 t/ha.

4. ***T 19:*** This medium tall and double podded variety has been developed by Department of Agriculture, U.P. The first blossom appears at 12-14th node after 60 days. Pods are yellowish green, slightly curved, 8.5 cm long with 6-7 wrinkled seeds with 45% shelling percentage.

5. ***Lincon*:** An introduced variety from USA released at Katrian. Plants are medium tall; first blossom appears at 11-12th node. It is double podded and pods are dark green, curved, big (8-9 cm long) with 8-9 wrinkled seeds. First picking starts 85-90 days after sowing. It is a good canning purpose variety. Average pod yield 10t/ha.

6. ***NP 29*:** This high yielding and wrinkled seeded plate variety was developed at IARI through selection. Plants are medium-tall with green foliage. First blossom appears at 14-16th node after 80 days from sowing. Pods are borne in double, green, straight, 7.5 cm long with 6-7 seeds. Shelling percentage 50. It is suitable for dehydration purpose.

7. ***Jawahar Matar 1 (JM1 or GC 141):*** This variety was developed at Jabalpur through advanced generation selections from the cross of T19 × Greater Progress. Plant height 65-70 cm, bushy, foliage green, flower white with two flowers per axil. Pods are straight and big (8.8 cm) with 8-9 big, sweet and wrinkled seeds. It is susceptible to powdery mildew disease. Average pod yield 12 t/ha with 52% shelling.

8. ***Jawsahar Matar 2 (JM 2):*** The variety was developed at Jabalpur through advanced generation selection from the cross of two exotic lines Greater Progress × Russian-2. Pods are dark green, big, curved with 8-10 sweet seeds. Seeds are wrinkled, green and bigger in size. It is susceptible to powdery mildew.

9. ***VL-Matar-3:*** This variety was developed at Almora through pedigree selection from the cross Old Sugar × Early Wrinkled Dwarf 2-2-1. Plant height 67 cm, determinate in habit with light green foliage, white flower and bear two pods in a bunch; pods are light green, 6.8 cm long, straight with 5 wrinkled seeds. Tolerant to powdery mildew and wilt; first picking starts 100 days after sowing. Average pod yield 10 t/ha with 46% shelling.

10. ***Pant Uphar (IP-3):*** This variety was developed at Pantnagar through selection. Pant height 70-75 cm with relatively thin leaflets of light green in colour, flower white and two buds are borne per axil; pods are round and 7-8 cm in length with yellowish and wrinkled seeds. First picking starts 75 to 80 days after sowing. Susceptible to powdery mildew disease, but tolerant against pea stem fly. Average pod yield 10 t/ha with 52% shelling.

11. ***Punjab 88 (P-88):*** This variety was developed at Ludhiana through selections from the hybrid progeny of the cross Pusa02 × Morrasis-55. Plants are dwarf, vigorous, erect with dark green foliage; one or two flowers per axil. Flowering after 75 days and first picking after 100 days of sowing. Pods are dark green, long (8-10 cm) and slightly curved at centre with 7-8 green, wrinkled and less sweet seeds. Highly susceptible to powdery mildew disease. Average yield 15 t/ha with 47% of shelling.

12. ***Azad P-2:*** A powdery mildew resistant variety developed at Kalyanpur through advanced generation selection from the cross Bonneville × 6587. Plants are tall (130-150 cm0, erect with light green foliage and white flowers. Pods are medium in size, light green, straight, smooth, firm borne in cluster of two with 6-7 wrinkled and brownish seeds. Crop duration 90-95 days. Average yield 12t/ha.

13. ***Vivek-6 (VL Matar-6):*** Developed at Almora through hybridization of Pant Uphar × VL Matar-3 and subsequent selections in advanced generations. Plants are dwarf, vigorous in advanced generations. Plants are dwarf, vigorous with dark green foliage and white flowers. Pods are light green, straight, medium sized (6-7 cm) and completely filled with 6 semi-wrinkled seeds of greenish white in colour. First picking starts 125-130 days after sowing. It is moderately tolerant to cold and moisture stress. Average yield 10-11 t/ha.

14. ***Ooty-1:*** Developed at Udhagamandalam through pure line selection from the accession PS 33. It is a dwarf type having yield potential of 11.9 t/ha in 90 days crop duration. It is resistant to white fly.

15. ***Jawahar Pea 83 (JP 83):*** This powdery mildew resistant variety was developed at Jabalpur through advanced generation selection the double cross (JMI × JP 829) × (46 c × JP 501). Plants are dwarf (50 cm), pods are big and curved with 8 big, green and sweet seeds. Average pod yield 12-13 t/ha.

16. ***Jawahar Peas 15 (JP 15):*** This duel resistant (powdery mildew and fusarium wilt) variety was developed at Jabalpur through advanced generation selections from the triple cross (JMI × R 98 B) × JP 501 A/2. Plants are dwarf (50 cm), having compact internodes and bigger pods containing 8 seeds. Average pod yield 13 t/ha.

***Arka Chaitra*:** Tall, mid-season variety, tolerant to high temperature (upto 35^0 C). Pods are long and light green coloured. Seeds are light green, round in shape and sweet. Pod yield: 7.0 t/ha in 90 days.

***Arka Uttam*:** Tall, mid-season variety, tolerant to high temperature (up to 35^0 C). Pods are long and dark green coloured. Seeds are dark green, round in shape and sweet. Pod yield: 7.0 t/ha in 90 days

***Arka Tapas*:** Medium tall, mid-season variety, tolerant to high temperature (upto 35^0 C). Pods are short and dark green coloured. Seeds are dark green, round in shape and sweet. Pod yield: 6.0 t/ha in 90 days.

Arka Mayur: Early variety, suitable for both kharif and rabi. Pods are short, straight and oval. Seeds are dark green, bold and sweet. Pod yield: 8.0 t/ha in 60 days.

Arka Harini: -Early variety, suitable for both kharif and rabi. Pods are straight and round with dark green, bold and sweet seeds. Pod yield: 8.0 t/ha in 60 days

Arka Nirmal: Early variety, suitable for both kharif and rabi. Pods are short, round and straight. Seeds are dark green and bold. Pod yield: 8.5 t/ha in 60 days.

Arka Apoorva : Mid-season and Whole pod edible pea variety. Pods are medium long, dark green coloured. Seeds are medium bold, dark green and very sweet, crisp in texture. Resistant to rust and powdery mildew. Pod yield: 11.0 t/ha in 90 days.

Arka Pramodh: Mid-season variety. Pods are green, broad and long. Seeds are bold, round, sweet and dark green in colour. Resistant to powdery mildew and rust. Pod yield: 12.0 t/ha in 90 days.

Arka Priya: Mid-season variety. Both pods and seeds are round and dark green colored. Seeds are very sweet and bold. Resistant to powdery mildew and rust. Pod yield: 12.0 t/ha in 90 days.

Arka Sampoorna: Mid-season and Whole pod edible pea variety. Pods are medium long, light green coloured. Seeds are medium bold, light green and sweet. Resistant to rust and powdery mildew. Pod Yield: 8.0 t/ha in 90 days.

Arka Karthik: Mid-season variety. Pods are medium long, green colored. Seeds are medium bold, green and sweet. Resistant to rust and powdery mildew. Pod Yield: 11.0 t/ha in 90 days.

Arka Ajit: Mid-season variety. Pods are medium long, light green coloured. Seeds are bold, green and sweet. Resistant to powdery mildew and rust. Pod Yield: 10.0 t/ha in 90 days.

Other improved varieties developed were **NDVP-8** and **NDVP-10** from Faizabad, **VL-8** from Almora, **Punjab 87** from Ludhiana, **Arka Ajit** (resistant to powdery mildew and rust and development by crossing Bonneville to the resistant lines followed by back crossing to Bonneville and subsequent selections) from IIHR.

Edible podded variety (Kamini, 2009):

Snow pea or sugar pea or snap pea. Whole pods of this type can be eaten as the pod walls contain less fibre and high sugar.

1. ***Sylvia*:** It is an introduced variety from Sweden. Plants are tall; first blossom appears at 14th to 16th node after 60 days of sowing. Pods are borne singly, yeelowish in colour, long (12 cm) and curved without parchment type pericarp. Pods are sweet and have general appearance of a medium sized French bean pod.

2. ***UN 53 (3):*** Developed at IIHR which gives 8-9 t pod yield per hectare in a crop duration of 90 days.

Field Pea Varieties (Vidhi, 2023):

In India, in initial stages, local cultivars were subjected to mass/pure-line selection and released. A very popular high yielding bold seeded cultivar T 163 was made popular in UP after purification of a local material from Bul and Shahr. **However, some popular field pea cultivars are listed in Table 4.**

Table 4. Field pea varieties released for different States of India

UP : Type 163, Rachna, DMR 11, B 22, Pant P 5, HUP 2
Bihar : BR 2, B 12 Swam Rekha, Rachna, DMR 11, T 163, Hans, HUP 2
West Bengal : B 22, B 12, Rachna, DMR 11, KUP 2
Delhi : Hans (L 116), Harbhajan (EC 33866), Rachna, DMR 11, Pant P 5
Maharashtra : Khoperkheda, Rachna, DMR 11, JP 885, Pant P 5
Himachal Pradesh : Kinnauri, Rachna, Hans, HPP 1
Punjab : PG 3, Rachna, Hans, Pant P 5
Haryana : Rachna, DMR 11, PG 3, Pant P 5
Rajsthan : Rachna, DMR 11, RP 3, T 163, Pant P 5
MP : Rachna, DMR 11, T 163, Hans, Pant P 5, JP 885
Rachna (T 163 x T 10) developed at CSAUAT, Kanpur was released in 1980 by UP State Variety Release Committee to replace T 163 as Rachna was claimed to be resistant to powdery mildew.
HPP 4 (Aparna) developed at CCS HAU, Hisar from a cross of T 163 x EC 109196 released in 1988 is classified as leafless type. It takes 145 days to mature and the grain yield potential is 25 q/ha. It is reported to be resistant to powdery mildew. A general survey of pedigree of early maturing vegetable peas and the field peas shows that Arkel is frequently used as one of the parents in case of vegetable type cultivars and T 163 in case of field pea cultivars.

Table 5 gives the Central and State released varieties of Field pea in India (FVI, 2023)

Table 5. Central and State released varieties of Field pea in India

Variety	Year of Release /Notification	Source	Area of adoption Zone/State	Maturity (Days)	Yield (q/ha)	Special feature
Prakash (IPFD 1-10)	2006	IIPR	**CZ** (MP., CG, MH, GJ, BK-UP **NWPZ** (PB, HR, DL, RJ, W- UP, Plains of UK), **NHZ** (J& K, HP,UK **NEH** (SK, NG, MG, MN, MZ TR, Aru.P.)	94-121	15-20	Res. to PM and tolerant to rust. Mod. resistant to pod borer and stem fly. plant height : 38-85 cm,
Paras	2006	IGKV,CG	**CZ**/ Chhattisgarh	92-119	18-24	Res. To PM. plant height: 48-71 cm, seeds- bold
Pant Pea-14	2006	GBPUAT,	**NWPZ**/ Uttarakhand	110-115	15-22	Medium variety. Resistant to rust and Powdery Mildew.
VL-Matar-42	2007	VPKAS	**NEPZ** (E- UP, BH, WB, JH, AS, J&K)	108-155	20	Resistant to PM, Moderate resistant to Rust
Pant Pea-25	2007	GBPUAT	NWPZ/ Uttarakhand	115-140	18-22	Resistance to PM and moderately resistant to Rust.
Hariyal (HFP-9907 B)	2007	CCSHAU	**NWPZ** (PB, HR, DL, RJ, W- UP, Plains of UK),	128-130	17-20	Suitable to Powdery Mildew & Root Rot; tolerant to Rust. No incidence of Pod Borer.
Pant Pea-42	2008	GBPUAT	**NWPZ** (PB, HR, DL, RJ, W-UP Plains of UK) **NHZ** (J& K, HP.,UK) **NEH** (SK, NG, MG, MN, MZ, TR, Aru.Pradesh)	113-139	22-23	Moderately resistant to Pod Borer and Stem Fly. Resist to Powdery Mildew and to Rust.
SwarnaTripti	2008	IARI	**NWPZ** (PB, HR, DL, RJ, W-UP Plains of UK),	65-70	25-30	Res. to powdery mildew. The variety is least affected by Pod Borer infestation; plant height: 100-105 cm.
HFP-9426	2008	CCSHAU	**NWPZ** (PB, HR, DL, RJ, W-UP Plains of UK),	135-140	20-21	Resistant to Powdery Mildew and better tolerant to Root-Rot. Moderately resistant to Nematodes.
Vivek Matar-10 (VP101)	2008	VPKAS	**NHZ** (J& K, HP., UK, **NEH** (SK, NG, MG, MN, MZ, TR, Aru.Pradesh)	120-130	25-30	Moderately resistance to Powdery Mildew and resistance to White Rot, Wilt & Leaf Blight. Less incidence of Pod Borer.
Pant P 13	2008	GBPUAT	**NWPZ** (PB, HR, DL, RJ, W-UP Plains of UK),	24-26	110-115	Resistant to powdery mildew.
Pant Pea -42	2008	GBPUAT	**NWPZ** (HR, PB, RJ., UP, UK)		113-149	Res. to PM, Rust. Mod. res. to Pod Borer and stem fly.
Pant Pea 74	2009	GBPUAT	**NWPZ** (PB, HR, DL, RJ, W-UP, Plains of UK),	120-130	22-23	Resistant to powdery mildew & Mod. resistant to Rust, Dwarf Type.
Aman (IPF 5-19)	2010	IIPR,	**NWPZ** (PB, HR, DL, RJ, W-UP, Plains of UK),	124-137	22-23	Res. to PM and tolerant to rust. Mod. resistant to Pod Borer and Stem fly. Plant height: 116 cm.
Gomati (TRCP-8)	2010	ICAR, Reas. Compl., Agartala	**NEHZ** (J& K, HP., UK, **NEH** (SK, NG, MG, MN, MZ, TR, Aru.Pradesh)	87-297	22-24	Tolerant to Pod Borer and Stem Fly. Tolerant to M. incognita and M. Javanica at different locations.
IPF 4-9	2011	IIPR	NEPZ/ UP	129	20-25	Resistant to PM and moderately resistant to Rust. Moderately resistant to Pod Borer and Stem Fly.
VL Matar 47 (VL47)	2011	VPKAS	NWPZ/ Uttarakhand	14.0	142-162	Resistant to wilt , Rust and powdery mildew
Dantiwada Pea-1 (SKNP 04-09)	2011	GAU	**NEPZ** (BH, JH, UP, WB.)	17.0	98-123	Resistant to powdery mildew
HFP-529	2012	CCSHAU	**NWPZ** (PB, HR, DL, RJ, W-UP, Plains of UK),	123-125	25-26	Resistant to Rust, PM, Aschochyta Blight, LCand CR. Mod. resistant to PB, Aphids, Leaf Miner and Stem Fly.
IPFD 10-12	2014	IIPR	**CZ** (MP,CG, MH, GJ, BK-UP)	110-115	22-25	Resistant to Powdery Mildew, Dwarf type
HFP 715	2014	CCS HAU	**NHZ** (J&K, HP., UK) **NEH** (SK, NG, MG, MN,MZ, TR, Aru.Pradesh)	115-120	15-16	Resistant to Powdery Mildew, Dwarf type
Punjab-89	2015	PAU	NWPZ/ Punjab	120	14-16	Resistant to Rust,
Kota Matar 1 (KPF 101)	2020	AU, Borkhera (Kota)	NWPZ/ Rajasthan	133	18-22	Resistant to moderately resistant against Powdery mildew, rust and root knot nematodes. Less incidence of pod borer.
IPFD 12-8 (Aakash)	2020	IIPR	NEPZ/ Uttar Pradesh	113-130	11-12	Resistant to powdery mildew and rust disease. Moderately resistant to pod borer.
IPFD 13-2 (Anant)	2020	IIPR	NEPZ/ Uttar Pradesh	106-138	13-15	Resistant to powdery mildew and rust disease. Moderately resistant to pod borer.
Pant Pea 250	2021	CCS HAU	**NWPZ** (HR, J&K, RJ, UP, PB, DL)	123	39	Resistant to Powdery mildew, Ascochyta blight and Root rot and moderately resistant to Rust.
HFP 1428	2021	CCS HAU	**NWPZ** (HR, J&K, RJ, UP, PB, DL)	123	39	Resistant to Powdery mildew, Ascochyta blight and Root rot and moderately resistant to Rust.

Note: Arun. P- Arunachal Pradesh, AS- Assam, BH-Bihar, CG-Chhattisgarh, DL-Delhi, GJ-Gujarat, HP-Himachal Pradesh, HR-Haryana, JH-Jharkhand, J&K – Jammu & Kashmir, MP-Madhya Pradesh, MH-Maharashtra, PB-Punjab, RJ-Rajasthan, SK-Sikkim, MG-Meghalaya, MN-Manipur, MZ-Mizorum, NG-Nagaland, TR-Tripura, UP-Uttar Pradesh, BK- UP = Bundelkhand region of Uttar Pradesh; UK-Uttarakhand, WB- West Bengal

- *W = Western; E= Eastern, N= Northern; BGM* = Botrytis grey mold, YMV-Yellow Mosaic Virus.
- Res.= Resistant, Tol.= Tolerant, Mod.= Moderately, PM= Powdery Mildew, PB-Pod Borer.

Table 6 gives the Central and State released varieties of Field pea in India (DPD, 2023).

Table 6. State-wise recommended varieties

State	Recommended varieties
Maharashtra	JP-885, Ambika, Indra (KPMR-400), Adarsh (IPF 99-25), IPFD 10-12
Gujarat	JP-885, IPFD 10-12, Indra, Prakash,
Punjab	Jay (KPMR-522), Pant pea-42, KFP-103 (Shikha), Uttra (HFP-8909), Aman(IPF5-19)
Haryana	Uttra (HFP-8909), DDR-27 (Pusa panna), Hariyal (HFP-9907 B), HFP-9426, Alankar, Jayanti (HFP-8712), Aman(IPF5-19)
Rajasthan	DMR-7 (Alankar), Pant Pea-42
M.P.	Prakash (IPFD 1-10), Vikas (IPFD -99-13)
U.P.	Swati (KFPD-24), Malviya Matar-15 (HUDP-15), Vikas, Sapna (KPMR-1441), IPF 4-9
Bihar	DDR-23 (Pusa Prabhat), V L Matar -42
C.G.	Shubhra (IM-9101), Vikas (IPFD -99-13), Paras
Uttarakhand	Pant Pea-14, Pant Pea-25, V L Matar -47
Jharkhand	PL Matar-42, V L Matar -42

USES

Three main types of pea cultivars can be distinguished: field pea, grown for the dry seeds; garden pea, grown for the immature green seeds; and sugar pea, grown for the immature pods. The dry seeds of field pea are first soaked in water to soften and are then boiled and consumed as a pulse dish. Alternatively, they are decorticated and split ('split peas') before boiling. They are also consumed roasted. The young pods of sugar pea are boiled for a few minutes only, to preserve their crispness; after boiling they may be stir-fried before consumption. The young seeds of garden pea are also boiled for a few minutes. They are commonly offered as canned or – in Western countries – as deep frozen products. In Ethiopia the annual consumption per person of pea seeds is estimated at 6–7 kg. Main dishes include 'shiro wot' (split pea seeds ground and made into stew) and 'kik wot' (split pea seeds boiled and made into stew). Snacks include 'eshet' (fresh green field pea seeds either eaten raw or roasted), 'nifro' (boiled dry or fresh green pea seeds) and 'endushdush' (seeds soaked first and then roasted). In local markets white- and cream-coloured seeds are preferred for 'kik'-making, and grey-coloured seeds for 'shiro'-making. In Malawi and some Asian countries, the young shoots are used as a leafy vegetable. In Western countries dry, mature pea seeds are extensively used as animal feed. The haulms or straw after threshing are used as forage, hay, silage and green manure. Apart from being an important source of food and feed, pea plays a role in soil fertility restoration as a suitable rotation crop that fixes atmospheric nitrogen. The seeds of pea are claimed to have beneficial effects on many types of skin complaints; face masks made from crushed seeds are used to treat acne and wrinkled skins (Messiaen *et al*., 2006).

By the 17th and 18th centuries, it had become popular to eat peas "green", that is, while they are immature and right after they are picked. This was especially true in France and England, where the eating of green peas was said to be "both a fashion and a madness". New cultivars of peas were developed by the English during this time, which became known as "garden" or "English" peas. The popularity of green peas spread to North America. Thomas Jefferson grew more than 30 cultivars of peas on his estate. With the invention of canning and freezing of foods, green peas became available year-round, and not just in the spring as before. The immature peas (and in snow peas the tender pod as well) are used as a vegetable, fresh, frozen or canned; varieties of the species typically called field peas are grown to produce dry peas like the split pea shelled from the matured pod. These are the basis of pease porridge and pea soup, staples of medieval cuisine; in Europe, consuming fresh immature green peas was an innovation of Early Modern cuisine. In modern times peas are usually boiled or steamed, which breaks down the cell walls and makes the taste sweeter and the nutrients more bioavailable. These formed an important part of the diet of most people in the Middle East, North Africa and Europe during the Middle Ages. Fresh peas are often eaten boiled and flavored with butter and/or spearmint as a side dish vegetable. Salt and pepper are also commonly added to peas when served. Fresh peas are also used in pot pies, salads and casseroles. Pod peas (particularly sweet cultivars called "sugar peas", or the flatter "snow peas,") are used in stir-fried dishes, particularly those in American Chinese cuisine. Pea pods do not keep well once picked, and if not used quickly, are best preserved by drying, canning or freezing within a few hours of harvest. In India, fresh peas are used in various dishes such as *aloo matar* (curried potatoes with peas) or *matar paneer* (paneer cheese with peas), though they can be substituted with frozen peas as well. Peas are also eaten raw, as they are sweet when fresh off the bush. Split peas are also used to make *dhal*, particularly in Guyana, and Trinidad, where there is a significant population of Indians. Dried peas are often made into a soup or simply eaten on their own. In Japan, China, Taiwan and some Southeast Asian countries, including Thailand, the Philippines and Malaysia, peas are roasted and salted, and eaten as snacks. In the Philippines, peas, while still in their pods, are a common ingredient in viands and pansit. In the UK, dried yellow split peas are used to make pease pudding (or "pease porridge"), a traditional dish. In North America, a similarly traditional dish is split pea soup. Pea soup is eaten in many other parts of the world, including northern Europe, parts of middle Europe, Russia, Iran, Iraq and India. In Sweden it is called *ärtsoppa*, and is eaten as a traditional Swedish food which predates the Viking age. This food was made from a fast-growing pea that would mature in a short growing season. *Ärtsoppa* was especially popular among the many poor who traditionally only had one pot and everything was cooked together for a dinner using a tripod to hold the pot over the fire. In Chinese cuisine, the tender new growth [leaves and stem] (*dòu miáo*) are commonly used in stir-fries. Much like picking the leaves for tea, the farmers pick the tips off of the pea plant. In Greece, Tunisia, Turkey, Cyprus, and other parts of the Mediterranean, peas are made into a stew with meat and potatoes. In Hungary and Serbia, pea soup is often served with dumplings and spiced with hot paprika. In the United Kingdom, dried, rehydrated and mashed marrowfat peas, known by the public as mushy peas, are popular, originally in the north of England, but now ubiquitously, and especially as an accompaniment to fish and chips or meat pies, particularly in fish and chip shops. Sodium bicarbonate is sometimes added to soften the peas. In 2005, a poll of 2,000 people revealed the pea to be Britain's seventh favourite culinary vegetable. Processed peas are mature peas which have been dried, soaked and then heat treated (processed) to prevent spoilage - in the same manner as pasteurising. Cooked peas are sometimes sold dried and coated with wasabi, salt, or other spices (Hai, 2015b).

Peas are part of many cuisines around the world. Fresh peas are widely used in pot pies, casseroles, and salads. Peas are also eaten by boiling and steaming them. Boiling and steaming breaks down the cell walls and makes the taste sweeter and nutrients more bioavailable. In India, peas are used in many curries. Pea milk is also extracted which is used as an alternative to cow milk. Sprouts or shoots of peas are also used in stir fries in East Asia (TS, 2022). In modern times peas are usually boiled or steamed, which breaks down the cell walls and makes the taste sweeter and the nutrients more bioavailable. Along with broad beans and lentils, these formed an important part of the diet of most people in the Middle East, North Africa and Europe during the Middle Ages. By the 17th and 18th centuries, it had become popular to eat peas "green", that is, while they are immature and right after they are picked. New cultivars of peas were developed by the English during this time, which became known as "garden" or "English" peas. The popularity of green peas spread to North America. Thomas Jefferson grew more than 30 cultivars of peas on his

estate. With the invention of canning and freezing of foods, green peas became available year-round, and not just in the spring as before (Wikipedia, 2023). Fresh peas are often eaten boiled and flavored with butter and/or spearmint as a side dish vegetable. Salt and pepper are also commonly added to peas when served. Fresh peas are also used in pot pies, salads and casseroles. Pod peas (snow peas and snap peas) are used in stir-fried dishes, particularly those in American Chinese cuisine. Pea pods do not keep well once picked, and if not used quickly, are best preserved by drying, canning or freezing within a few hours of harvest (Wikipedia, 2023). In India, fresh peas are used in various dishes such as *aloo matar* (curried potatoes with peas) or *mattar paneer* (paneer cheese with peas), though they can be substituted with frozen peas as well. Peas are also eaten raw, as they are sweet when fresh off the bush. Green Peas known as Hasiru Batani in Kannada are used to make curry and Gasi. Split peas are also used to make *dal*, particularly in Guyana, and Trinidad, where there is a significant population of Indians (Wikipedia, 2023).

Dried peas are often made into a soup or simply eaten on their own. In Japan, China, Taiwan and some Southeast Asian countries, including Thailand, the Philippines and Malaysia, peas are roasted and salted, and eaten as snacks. In the Philippines, peas, while still in their pods, are a common ingredient in viands and pansit. In the UK, dried yellow or green split peas are used to make pea pudding (or "pea porridge"), a traditional dish. In North America, a similarly traditional dish is split pea soup. Pea soup is eaten in many other parts of the world, including northern Europe, parts of middle Europe, Russia, Iran, Iraq and India.[43] In Sweden it is called *ärtsoppa*, and is eaten as a traditional Swedish food which predates the Viking Age. This food was made from a fast-growing pea that would mature in a short growing season. *Ärtsoppa* was especially popular among the poor, who traditionally only had one pot and everything was cooked together for a dinner using a tripod to hold the pot over the fire. In Chinese cuisine, the tender new growth [leaves and stem] dou miao are commonly used in stir-fries. Much like picking the leaves for tea, the farmers pick the tips off of the pea plant. In Greece, Tunisia, Turkey, Cyprus, and other parts of the Mediterranean, peas are made into a stew with lamb and potatoes. In Hungary and Serbia, pea soup is often served with dumplings and spiced with hot paprika. In the United Kingdom, dried, rehydrated and mashed marrowfat peas, or cooked green split peas, known as mushy peas, are popular, originally in the north of England, but now ubiquitously, and especially as an accompaniment to fish and chips or meat pies, particularly in fish and chip shops. Sodium bicarbonate is sometimes added to soften the peas. In 2005, a poll of 2,000 people revealed the pea to be Britain's seventh favourite culinary vegetable (Wikipedia, 2023). Processed peas are mature peas which have been dried, soaked and then heat treated (processed) to prevent spoilage—in the same manner as pasteurizing. Cooked peas are sometimes sold dried and coated with wasabi, salt, or other spices. In North America pea milk is produced and sold as an alternative to cow milk for a variety of reasons (Wikipedia, 2023).

As a side dish vegetable, fresh peas are commonly boiled and flavoured with butter and/or spearmint. When serving peas, salt and pepper are often used. Fresh peas can also be used in casseroles, salads, and pot pies. Pod peas (also known as snow peas or snap peas) are commonly used in stir-fried dishes, particularly in American Chinese cuisine. Peapods do not hold well once picked, and if not used right away, they should be dried, canned, or frozen within a few hours of harvest. Fresh peas are widely used in Indian dishes such as aloo matar (curried potatoes with peas) and matar paneer (paneer cheese with peas), though frozen peas may also be used. Peas may also be eaten raw because they are sweet when picked straight from the forest. Northern Europe, portions of Middle Europe, Russia, Iran, Iraq, and India are among the countries that consume pea soup. It's known as ärtsoppa in Sweden, and it's a traditional Swedish dish. This food was made from a pea that grew rapidly and matured in a short period of time (Vedantu, 2023). Ways of eating: Fresh peas are often eaten boiled and flavored with butter and/or spearmint as a side dish vegetable. Salt is also commonly added to peas when served. Fresh peas are also used in pot pies, salads and casseroles. Pod peas (particularly sweet cultivars called *mangetout* and *sugar peas*, or the flatter "snow peas," are used in stir fried dishes, particularly those in American Chinese cuisine. Pea pods do not keep well once picked, and if not used quickly are best preserved by drying, canning or freezing within a few hours of harvest (Wikipedia, 2023a). Dried peas are often made into a soup or simply eaten on their own. In Japan and other Southeast Asian countries including Thailand, Taiwan and Malaysia, the peas are roasted and salted, and eaten as snacks. In the UK, marrowfat peas are used to make pease pudding (or "pease porridge"), a traditional dish. In North America a similarly traditional dish is split pea soup (Wikipedia, 2023a). In Chinese cuisine, pea sprouts are commonly used in stir-fries and its price is relatively high due to its agreeable taste (Wikipedia, 2023a). Pea sprouts: In East Asia, the sprouts or shoots of pea were once dedicated cuisine when the plant was not highly available as nowadays. But now, when the plant can be easily grown, fresh pea shoots are available in supermarkets, and some people decided to grow them in their backyard (Wikipedia, 2023).

Frozen peas: In order to freeze and preserve peas, they must first be grown, picked, and shelled. Usually, the more tender the peas are, the more likely that they will be used in the final product. The peas must be put through the process of freezing shortly after being picked so that they do not spoil too soon. Once the peas have been selected, they are placed in ice water and allowed to cool. After, they are sprayed with water to remove any residual dirt or dust that may remain on them. The next step is blanching. The peas are boiled for a few minutes to remove any enzymes that may shorten their shelf life. They are then cooled and removed from the water. The final step is the actual freezing to produce the final product. This step may vary considerably; some companies freeze their peas by air blast freezing, where the vegetables are put through a tunnel at high speeds and frozen by cold air. Finally, the peas are packaged and shipped out for retail sale (Wikipedia, 2023).

Medical Use: Some people are allergic to peas and lentils, with vicilin or convicilin being the most common allergens. Jews, other Middle Eastern Semitic peoples, and other descendants of the Mediterranean coastal regions are affected by Favism, or Fava-bean-ism, a hereditary deficiency of the enzyme glucose-6-phosphate dehydrogenase. Hemolytic anaemia is the toxic reaction to consuming most, if not all, beans in this state, and the released circulating free haemoglobin cause acute kidney injury in extreme cases (Vedantu, 2023).

Ethnobotanical Uses: *Pisum sativum* is a global food crop, including edible-pod peas as well as field and garden peas. Its seed, especially the oils, may be contraceptive. Powdered seed can also treat skin irritation and acne. Flowers are edible in a raw state. The top 10-15 cm of pea plants are used in salads, stir-fries, and as decorative garnishes as a traditional Indochinese crop. From research into pea vine edibility comes the following wisdom: Remove tendrils before cooking/preparing pea vines as a vegetable. Taiwanese saying: “tendrils tie your tongue” (Burnham *et al.,* 2013)**.**

NUTRITIONAL VALUE

Pea is a rich source of protein, amino acids, and carbohydrate. Peas are used alone and also mixed with other vegetables. Peas are processed for freezing, canning, and dehydration in the immature stage (Kalloo and Bergh, 1993).

Whole mature dried seeds of field pea contain per 100 g edible portion: water 13.3 g, energy 1269 kJ (303 kcal), protein 21.6 g, fat 2.4 g, carbohydrate 52.0 g (starch 47.6 g), fibre 15.0 g, Ca 61 mg, Mg 120 mg, P 300 mg, Fe 4.7 mg, Zn 3.7 mg, carotene 245 µg, thiamin 0.6 mg,

riboflavin 0.3 mg, niacin 3.0 mg, vitamin B_6 0.13 mg, ascorbic acid trace. The content of essential amino acids per 100 g food is: tryptophan 210 mg, lysine 1620 mg, methionine 210 mg, phenylalanine 1000 mg, threonine 860 mg, valine 1000 mg, leucine 1480 mg and isoleucine 930 mg. The composition of wrinkled pea seeds is different from rounded ones; they have less starch (27–37 g) and more fat (5 g) and sugars. Antinutritional factors in pea seeds include trypsin inhibitors, haemagglutinins (lectins), tannins, oligosaccharides and phytate. Cultivars with a darker seed coat contain more tannin, which tends to decrease their digestibility (Messiaen *et al.,* 2006).

Raw garden pea seeds, immature taken from the pods (refuse 63%) contain per 100 g edible portion: water 74.6 g, energy 348 kJ (83 kcal), protein 6.9 g, fat 1.5 g, carbohydrate 11 3 g (starch 7.0 g), fibre 4.7 g, Ca 21 mg, Mg 34 mg, P 130 mg, Fe 2.8 mg, Zn 1.1 mg, carotene 300 µg, thiamin 0.75 mg, riboflavin 0.02 mg, niacin 2.5 mg, folate 62 µg, ascorbic acid 24 mg (Messiaen *et al.,* 2006).

Raw sugar pea pods, with the ends trimmed (refuse 8%) contain per 100 g edible portion: water 88.7 g, energy 134 kJ (32 kcal), protein 3.6 g, fat 0.2 g, carbohydrate 4.2 g (starch 0.8 g), fibre 4.2 g, Ca 44 mg, Mg 28 mg, P 62 mg, Fe 0.8 mg, Zn 0.5 mg, carotene 695 µg, thiamin 0.2 mg, riboflavin 0.15 mg, niacin 0.6 mg, folate 10 µg, ascorbic acid 54 mg (Messiaen, et al., 2006).

Peas are starchy, but high in fiber, protein, vitamin A, vitamin B6, vitamin C, vitamin K, phosphorus, magnesium, copper, iron, zinc and lutein. Dry weight is about one-quarter protein and one-quarter sugar. Pea seed peptide fractions have less ability to scavenge free radicals than glutathione, but greater ability to chelate metals and inhibitlinoleic acid oxidation **(Hai, 2015b).** Peas are a rich source of protein (23–25%), essential amino acids, complex carbohydrates, and mineral content like iron, calcium, and potassium. They are naturally low in sodium and fat. Today peas are used in soups, breakfast cereals, processed meat, health foods, pasta, and purees; they are processed into pea flour, starch, and protein. They are one of the eight so-called "founder crops" and among the earliest domesticated crops on our planet (Hirst, 2019).

The nutritional content of 100 g of green peas in given in the **Table 7** (TS, 2022) **:**

Table 7. The nutritional content of 100 g of green peas

Calories	81
Protein	5.42 g
Fat	0.4 g
Dietary Fiber	5.1 g
Sugars	5.67 g
Calcium	25 mg
Potassium	244 mg
Vitamin C	40 mg
Iron	1.47 mg

Though small in size, peas are a storehouse for essential nutrients such as vitamins, minerals, and fibers. Vitamin A, B6, and C are some of the main vitamins present in green peas that provide them with a certain beneficial quality. With minerals such as potassium, consuming peas as a part of your regular diet can reduce blood pressure and lowers the risk of stroke (Joshi, 2023). **Tables 8 and 9** give Nutritional Value of Peas, green, raw (fresh) and Nutritional Value of Split peas, raw (dried) (Wikipedia, 2023)

Table 8. Nutritional Value of Peas, green, raw (fresh)

Nutritional value per 100 g (3.5 oz)	
Energy	339 kJ (81 kcal)
Carbohydrates	14.45 g
Sugars	5.67 g
Dietary fiber	5.1 g
Fat	0.4 g
Protein	5.42 g
Vitamins	**Quantity %DV†**
Vitamin A equiv. beta-Carotene lutein zeaxanthin	5% 38 µg 4% 449 µg 2477 µg
Thiamine (B1)	23% 0.266 mg
Riboflavin (B2)	11% 0.132 mg
Niacin (B3)	14% 2.09 mg
Vitamin B6	13% 0.169 mg
Folate (B9)	16% 65 µg
Vitamin C	48% 40 mg
Vitamin E	1% 0.13 mg
Vitamin K	24% 24.8 µg
Minerals	**Quantity %DV†**
Calcium	3% 25 mg
Iron	11% 1.47 mg
Magnesium	9% 33 mg
Manganese	20% 0.41 mg
Phosphorus	15% 108 mg
Potassium	5% 244 mg
Sodium	0% 5 mg
Zinc	13% 1.24 mg

Table 9. Nutritional Value of Split peas, raw (dried)

Nutritional value per 100 g (3.5 oz)	
Energy	1,425 kJ (341 kcal)
Carbohydrates	60 g
Sugars	8 g
Dietary fiber	26 g
Fat	1 g
Protein	25 g
Vitamins	**Quantity %DV†**
Thiamine (B1)	61% 0.7 mg
Pantothenic acid (B5)	34% 1.7 mg
Folate (B9)	69% 274 µg
Minerals	**Quantity %DV†**
Iron	31% 4 mg

HEALTH BENEFITS

According to **Hai (2015b) the following are the health benefits of peas:**

1. Weight Management: Peas are low fat but high everything else. A cup of peas has less than 100 calories but lots of protein, fiber and micronutrients.

2. Stomach cancer prevention: Peas contain high amounts of a health-protective polyphenol called coumestrol. A study in Mexico City determined you only need 2 milligrams per day of this phytonutrient to prevent stomach cancer. A cup of peas has at least 10.

3. Anti-aging, strong immune system, and high energy: This comes from the high levels of anti-oxidants including:
- Flavinoids: = catechin and epicatechin
- Carotenoid = alpha-carotene and beta-carotene
- Phenolic acids = ferulic and caffeic acid
- Polyphenols = coumestrol

4. Prevention of wrinkles, alzheimer's, arthritis, bronchitis, osteoporosis and candida: These come from peas strong anti-inflammatory properties. Excess inflammation has also been linked to, heart disease, cancer, and aging in general. These properties include: Pisumsaponins I and II and pisomosides A and B are anti-inflammatory phytonutrients found almost exclusively in peas. Vitamin C and vitamin E, and a good amount of the antioxidant mineral zinc. Omega-3 fat in the form of alpha-linolenic acid (ALA).

5. Blood sugar regulation: High fibre slows and protein slows down how fast sugars are digested. The anti-oxidants and anti-inflammatory prevent or reverse insulin resistance (type 2 diabetes). All carbohydrates are natural sugars and starches with no white sugars or chemicals to worry about.

6. Heart disease prevention: The many antioxidant and anti-inflammatory compounds support healthy blood vessels. The formation of plaque along our blood vessel walls starts with chronic, excessive oxidative stress and inflammation. The generous amounts of vitamin B1 and folate, B2, B3, and B6 reduce homocysteine levels which are risk factor for heart disease.

7. Healthy for the environment: Peas work with bacteria in the soil to 'fix' nitrogen from the air and deposit it in the soil. This reduces the need for artificial fertilizers since one of their main ingredients is nitrogen. After peas have been harvested the remaining plant easily breaks down to create more organic fertilizer for the soil.
Peas are also able to grow on minimal moisture so they are a perfect crop in many areas not needing irrigation or using up valuable water supplies.

8. Prevent constipation: The high fiber content in peas improves bowel health and peristalsis.

9. Healthy bones: Just one cup of peas contain 44% of your Vitamin K which helps to anchor calcium inside the bones. It's B vitamins also help to prevent osteoporosis.

10. Reduces bad cholesterol: The niacin in peas helps reduce, the production of triglycerides and VLDL (very low-density lipoprotein, which results in in less bad cholesterol, increased HDL ("good") cholesterol, and lowered triglycerides.

According to Joshi (2023) the following are the health benefits of peas:

1. Peas have an antioxidant quality: Due to their antioxidant properties, green peas are quite effective in acting as a free radical scavenger. Peas are loaded with different kinds of vitamins. They have a robust free-radical scavenging antioxidant property linked with their consumption. Free radicals, or free oxygen atoms, are present in the bloodstream. These free-roaming particles are responsible for combining with healthy cells and exerting oxidative stress over the cell walls, thus damaging them in the process. Free-radical damages are typically linked with age-related concerns and tissue inflammation problems. However, an antioxidant-rich diet can lower the free radical concentration in the bloodstream. This, in turn, lowers the risk of free radical damage, thus keeping the age-related concerns at bay.

2. Good for weight loss: One of the macro-nutrient present in peas is fiber, and they are particularly loaded with it. Dietary fiber is referred to as the non-digestible part of the food, and hence it requires more time to digest them. This is part of the reason why peas are essential for weight loss, as they help in keeping you filled for long and prevent you from overeating. In addition to that, a fiber-filled food item is harder for the stomach to digest and requires an extra amount of work from your stomach. Due to this, your body ends up burning more calories (as peas are low in calories). This also makes peas a negative calorie food, as it promotes weight loss by burning a few calories and improving metabolism.

3. Manages blood sugar: This is another benefit of green peas that is derived from the presence of high fiber. As fiber helps in slowing down the digestion process, we can state that this leads to slower absorption of glucose by the system. This, in turn, gives the pancreas enough time for the secretion of an appropriate amount of insulin (a hormone used for breaking down glucose molecules into energy), thus preventing sudden spikes in blood sugar levels.

4. Improves immunity: The antioxidant quality of peas also comes into play when it comes to strengthening your immunity. These antioxidants are responsible for protecting immune cells from the attack of free radicals. Furthermore, adequate consumption of antioxidants can help lower the rate of progression of age-related disorders such as Alzheimer's or Parkinson's disease.

5. Peas are a great choice for pregnant women: The high quantity of folate present in fresh peas helps in the overall development of the baby's nervous system during pregnancy. Peas are a rich source of folate, which is also considered to be one of the essential nutrients during pregnancy. It can contribute to the healthy development of the child's brain and spinal cord. A daily intake of 400 micrograms of folate might just be enough for this purpose. By increasing the production of red blood cells, the consumption of folate helps develop the neural tube development that benefits the brain and the spinal cord of the baby.

6. Great for vision – Benefits of green peas for eye health: There is a reason why people often advise others to opt for green vegetables to improve their eyesight. Peas are particularly rich in vitamin A, which in turn is an essential element for better vision. This vitamin helps protect the eye's surface against damaging free radicals and helps maintain a healthy mucous membrane. Other antioxidants, such as lutein and carotenes, which are also present in peas, further accelerate its work and make it more efficient.

7. Increases the level of oxygen in the system: Apart from potassium, the other mineral present in peas is iron, which plays an essential role in the transfer of oxygen throughout the system. Iron is an essential mineral that aids in hemoglobin production (the oxygen-carrying cell in the bloodstream). Thus, having a diet loaded with iron would eventually aid in the healthy production of hemoglobin and increase oxygen supply to every other organ, ensuring their proper functioning. Moreover, the consumption of peas, which are riddled with iron, helps in the prevention of other oxygen deficiency disorders, such as anemia.

8. Maintains blood pressure: Thanks to the adequate amount of phosphorus present in peas, their consumption has proven to be quite important for controlling your blood sugar. Minerals such as phosphorus exert a dilating effect on the inner lining of the blood vessels and can prevent them from constricting, which helps in lowering the blood pressure.

9. **Benefits of peas in strengthening bone structure**: Though vitamin D is a necessity for the development of bones, it does not work as well all by itself. The other requirement for the maintenance of one's bone structure is vitamin K, which is abundantly present in peas. Vitamin K works alongside calcium in increasing the structural density of your bones. It helps in anchoring the calcium inside of the bones, thus lowering its rate of removal by the body.

Side-effects of peas: Every food item that we consume has some sort of side-effects linked with their consumption, and there is no surprise that an unregulated consumption of peas can also be damaging to one's health. One major side-effect linked with their heavy consumption is the rising level of Vitamin K in your system. Though this vitamin is quite essential when it comes to keeping your bones healthy, a high level of vitamin K can also thin your blood and lowers its platelet count. This could further result in slower wound repair and heavy blood loss. Its high dietary fiber content can also have a negative effect on your health. Fibers are responsible for slowing down your digestion, thus it requires your body an extra amount of time to completely digest it. If you load up too much on fibers, it might lead to excessive weight gain, which is the opposite of their weight-loss benefit.

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