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REVIEW ARTICLE

GENETICS AND BREEDING OF PEA

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ABSTRACT

Pea (*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 highly self – pollinated due to cleistogamous flower structure and has less than one percent out crossing. 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. 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 presence 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 pods 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.

INTRODUCTION

It is the cool season crop of temperate and subtropical regions. It can also be grown in mild climate of the tropics. It is also one of the most popular vegetables grown for home use by home gardeners. The word is derived from the Greek pison, which in Middle English became pease and was later shortened to pea. In India peas are grown as winter vegetables in plains and as summer vegetable in the hills. In India pea is extensively cultivated in Uttar Pradesh, Bihar and Madya Pradesh. It is also grown in Haryana, Punjab, parts of Rajasthan, Himachal Pradesh, Jammu and Kashmir, West Bengal, Orissa, Maharashtra and Karnataka. The important producers of pea in the world are U.S.A, China, France, U.K , Holland, Hungary, Russia, Egypt and Australia.

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Varieties and cultivars

Peas are grown for use as a fresh or processed vegetable and mainly wrinkled seeded varieties are grown. In selecting a variety for a given situation, there are four major considerations:

1. Timing, because they are early, medium and late varieties.
2. Size whether dwarf, semi dwarf or tall.
3. Smooth or Wrinkled seeds.
4. Edible or Non edible pods.

Two varieties Meteor and Clipper are the most popular wrinkle seeded variety. All of these belong to first early group. In the second early group, mainly wrinkle seeded varieties such as Little Marvel and Kelvedon Triumph are widely grown. The round seeded variety in this group is Laxton Superb. The main season varieties are all wrinkled seeded include Onward, Lincoln, Alderman, Duplex, and Gaint Stride. For crops of tall peas, Alderman is favoured. There are some late varieties such as Gladstone.The canning industry prefers the small peas because of its high quality. The varieties grown for freezing must have the dark green colour and tender skins. Thomas laxton is the most widely freezing variety.

Other wrinkled seeded varieties include Emerald and Louisiana purchase from the Florida and Louisiana agricultural experiment stations. The latter is a semi viny type producing pods with 14-16 peas. For edible podded peas intended for home gardens and small, the dwarf grey sugar variety is the earliest and smallest of the sugar peas. A larger and late variety, mammoth melting sugar, is resistant to fusarium wilt and requires support to climb.

GENETICS

1) Inheritance of qualitative characters

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 presence 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. The leaflets are converted into tendrils by the gene, af, double leaflet and stipule area, lat, tendrils present on acacia leaves, tac and leaves with extra leaflets and no tendrils, stem fasciation is controlled by two single recessive genes fa and fas along with each other. The wax or bloom trait is inherited by single recessive genes, such as wa for absence of wax on pods, upper and lower stipule surfaces and underside of leaflets, wb for pods without wax, little wax on rest of plants and wel for absence of wax from all parts of plant. The colour of plant and its parts, like foliage, flower, and seed are also governed by single recessive genes, like for absence of anthocyanin in plants, flower and seed, ch-l for light yellow green plant, d for green leaf axil, pa for dark green immature seed and foliage and vm with effect similar to pa. The number of flowers on the inflorescence is controlled by two different recessive single genes, fn and fna in the presence of each other. The gene b is for pink flower and ce for rose coloured flowers and both are dependent on the dominant a for manifestation of colour. Single recessive genes determine various seed characteristics, like flattened seed sides (com), dimpled seed (di), wrinkled seed cotyledon (r,rb), gritty seed surface (gty), and green cotyledons (i), and black hilum by dominant gene pi along with ar and b. A single recessive gene it increases pod width 25% the dominant gene con effects curvature of pods, dominant bt for blunt apex of pods and recessive n for thick pod wall. Tough and leathery pods that dehisce readily at maturity are due to the presence of a dominant single gene, 'p' and 'v' are responsible for reducing or eliminating sclerenchymatous membrane on inner pod walls. The purple pod colour is governed by two dominant genes pu and pur, along with the dominant gene a and yellow colour of young pods by a recessive gene gp.

2) Inheritance of disease resistance

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. Single recessive genes are resistance to pea seed borne mosaic virus (sbm), Powdery mildew (er; er-2), Bean yellow mosaic virus (mo), Top yellow Virus, Pea Streak Virus, Pea mosaic virus (pmv), and Bean virus 2. Resistance to Ascochyta blight (ascochyta pisi) is governed by duplicate factors or single dominant genes. Linked polygenes with a recessive gene (le or pl), or single dominant gene are for resistance to Pea Root Rot, Aphanomyces euteiches. The resistance to Bacterial Brown spot of Pea, Pseudomonas syringe pv. pisi, is due to a complex system of inheritance.

3) Inheritance of quantitative characters

The highly heritable polygenic characters are plant height, earliness, number of pods per plant, pod length,

PLANT HEIGHT

GENE	CHARACTER
cry	**Influences internode length and plant height along with la and le**
la	Internode length and plant height along with cry and le
le	Internode length and plant height along with cry and la

Wax (bloom)

wa	**Without wax on pods, upper and lower stipules surfaces and underside of leaflets**
Wb	Pods without wax, little wax on rest of plants.
Wel	Wax absent from all parts of the plant

Branching

Fr	**With fru determines number of basal branches**
Fru	With fr determines number of basal branches
Ram	Increases number of branches

Leaves and Stipules

Af	**Leaflets converted into tendrils**
Lat	Double leaflet and stipule area
Tac	Tendrils present on acacia leaves
Tl	Leaves with extra leaflets and no tendrils

Colour

A	**Absence of anthocyanin; dominant allele for anthocyanin production in plant, flower and seed**
ch-l	Plant light yellowish green
D	Green leaf axil; dependant on a for manifestation of colour
Pa	Dark green immature sed and foliage
Vm	Effect similar to pa

Inflorescence, Number of flowers

fn	**With fna determines number of flower on the inflorescence; greatly influenced by environment**
fna	With fn determines number of flowers on the inflorescence, greatly influenced by environment

Fasciation

fa	**Stem fasciation with fas**
fas	Stem fasciation with fa

Flower colour

b	**Flower pink;dependent on a for manifestation of colour**
Ce	Flower rose; dependent on a for manifestation of colour

Seeds

Com	**Sides of seeds flattened**
Di	Small dimpled depressions in seed; observable only with a r seed
R	Seed cotyledons wrinkled
Rb	Seed cotyledons wrinkled
Gty	Gritty seed surface
I	Green cotyledons;/produces yellow cotyledons
Pl	Hilum black with a ar b

Pods

It	**Increases pod width 25%**
Bt	Apex of pods blunt
Con	Affects curvature of pods
N	Pod wall thick
Dpo	Pods tough and leathery; readily dehisce at maturity
P	Reduces or eliminates sclerenchymatous membrane on inner pod wall
V	Same as p
Gp	young pod yellow

GENETICS OF DISEASE RESISTANCE IN PEA

INHERITANCE	DISEASE RESISTANCE
Single dominant gene,en	Resistance to enation mosaic virus
Single dominant gene, fnw	Resistance to Fusarium oxysporum f.pisi race 2, Near Wilt
Single dominant gene, fw	Resistance to Fusarium oxysporum f.pisi race 1, Fusarium wilt
Single recessive gene, sbm	Resistance to pea seed borne mosaic virus
Single recessive gene,er	Resistance to Powdery mildew (Erysiphe polygoni)
Single recessive gene,er-2	Resistance to powdery mildew (Erysiphe polygoni)
Monogenic, dominant	Brown root of peas, Fusarium solani f.sp.pisi, resistance dominant
Monogenic, dominant	Rust, Uromyces fabae, resistance dominant
Monogenic, dominant	Downy mildew, Perenospora pisi, resistance dominant
Duplicate factor; or Single dominant gene	Resistance to Ascochyta blight, (Ascochyta pisi)
Single recessive gene (mo)	Bean yellow mosaic virus
Monogenic recessive	Top yellow virus
Single recessive gene	Pea leaf roll virus
Single recessive gene	Pea streak virus
Single recessive gene (pmv)	Pea mosaic virus
Single recessive gene	Bean virus 2

seeds per pod and 100 seed weight. Pod yield has low heritability. The number of pods per plant, number of seeds per plant, 100 seed weight, number of days to maturity and plant height had direct effect on yield. The number of pods per inflorescence, number of seeds per pod, and seed weight, besides plant height, leaf area,

number of branches, early flowering and number of pods had direct association with yield. The number of gene action, degree of dominance, and inter allelic gene effect were studied for different plant characters. 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.

GENETICS OF POLYGENICALLY CONTROLLED QUANTITATIVE TRAITS IN PEA

CHARACTER	INHERITANCE / GENE ACTION
Plant height	High Heritability, Over dominance, Partial dominance, High genetic advance
Days to flowering	Non-additive gene action, Partial dominance, Over dominance
Earliness	Dominant genes; High heritability
Late flowering	Recessive genes; High heritability
First node bearing flower	Dominant gene action; Partial dominance
Number of pods per plant	High heritability; Epistatic gene action positive; High genetic advance
Pod length	High heritability
Seed per pod and Test weight	High heritability; Additive gene action and High genetic advance for 100 seed weight
Seeds per plant	Epistatic gene action positive; Additive, dominance and Over dominance
Pod yield	Low heritability
Cold resistance	Intermediate dominance, Polygenic, many recessive genes

BREEDING OBJECTIVES

THE FOLLOWING ARE THE MAIN OBJECTIVES OF PEA BREEDING :

1. Early maturity, preferably 50-60 days after seed sowing.
2. Other desired maturities may be mid season (80-90 days) and late (100-120 days).
3. Pod characteristics, like colour, size, apex (blunt or pointed) and shape, straight, or curved, number of pods per plant.
4. Seeds size (100 seed weight), number per pod, number per plant, colour, shape, round, coloured, dimpled, or wrinkled or smooth, colour greenish, white or yellowish.
5. Sheeling percentage- ratio between weight of green pods and weight of seeds in mature green pods, expressed in percentage, about 40% or more.
6. Pod yield (green mature pods).
7. Suitability for processing, mainly canning, dehydration, and freezing.
8. Resistance to diseases, like Powdery mildew, (Erysiphe polygoni), Downy mildew (Perenospora pisi), Rust (Uromycese fabacae), Wilt (Fusarium oxysporum f. pisi) and Virus diseases (Pea seed-borne mosaic, Pea Enation mosaic, Bean yellow mosaic).
9. Resistance to Insect pests, like Leaf miner (Phytomyza atricornis), Stem fly (Ophiomyia phaseoli), pod borer (etiella zinckenella), pea aphid (acyrthosiphon pisum), weevil / bruchus (callosobruchus chinensis) and a few others.
10. Resistance to abiotic stresses, such as, heat, cold, frost,drought and water logging.

IMPORTANT DONORS FOR PEA BREEDING PROGRAMME:

SINGH (1991, 1995) has compiled information on genetics and breeding of peas including listing of superior lines with multiple gene resistance in pulse crops. Kalloo (1993) and Narsinghani and Tewari (1993) has also given detailed account of pea breeding. A few examples of pea are given below:

1	Earliness	ASAUJI, LUCKNOW,BONIA,HANS,EC 3
2	More pods/plant	PLP 26, 50, 69, 179, 279, 496
3	Long pods	EC 109171, 109176, 109190, 109195
4	Bold pods	EC 4103, 6185, 95924
5	Powdery mildew	EC 326, 42529, 109190, 109196, T 10, P 185, P 288, PC 6578, B 4048,P 6587, P 6588, BHU 159, IC 4604, JP 501,VP 7906
6	Wilt	Early Perfection, Bonneviella, PL 43, 124, 6101, Glacier
7	Rust	PJ 207508, 222117, EC 109188, EC 42959, IC 4604, PJ 207508, JP Batri Brown 3, JP Batri Brown 4
8	Pea mosaic	America Wonder, Perfection Canner's Gem, Dwarf White Sugar, Little Marvel
9	Leaf miner	EC 16704, 21711, 25173
10	Pea stem fly (Tolerant)	Dwarf Grey Sugar, T 10, T 163

BREEDING METHODS

Pea is highly self – pollinated due to cleistogamous flower structure and has less than one percent outcrossing. The breeding method of selection, recurrent selection, hybridization, backcrossing and induced mutation. Hybridization, back crossing line breeding and recurrent selection methods have been adopted in breeding for disease resistance.

Improvement of pea by breeding has been undertaken at PAU (Ludhiana), HAU (Hissar), GBPUAT (Pantnagar), JNKVV (Jabalpur), CSAU (

Kanpur), Dr. YSPUHF (Solan), IARI (Delhi), PDVR (Varanasi), NDUAT (Faizabad) and VL (Almora). The improvement of garden pea/vegetable pea in India started much later than field pea, around the year 1940.

The main emphasis in pea improvement has been on early maturity, yield, quality, and resistance to diseases and insect pests. Intensive work has been undertaken on breeding for resistance to diseases (powdery mildew, fusarium wilt and rust) and insect pests (bruchus, leaf miner) at JNKVV, Jabalpur. Breeding for resistance to leaf miner has also taken up at HAU, Hisar.

The important garden pea varieties developed in the country. These are high yielding, early maturing or mid season cultivar with attractive long pods, wrinkled seeds, good 100 seed weight and high shelling percentage. There are three types of pea varieties based on maturity, namely early, mid season and late. In the early group, green pods are ready for picking after 50-60 days of seed sowing and after 80-90 days in mid season group. The late varieties take about 100 days or more for first picking of pods. Most of these cultivars have wrinkled seeds, except the early maturing local cultivars in which seeds are smooth/ round. However the variety Arkel

IMPORTANT GARDEN PEA CULTIVARS DEVELOPED IN INDIA AND A FEW IMPORTANT EXOTIC VARIETIES

Cultivar	Parentage	Maturity (No. Of Days)	Yield (tonnes/ha)	Source
Early group				
Arkel	Introduction from England	55 – 60	10 (40%)*	IARI, NewDelhi
Pusa pragati		60 – 65	7	IARI, NewDelhi
Jawahar matar 3	T19 * Early badger	50	5	JNKVV,Jabalpur
Jawahar matar 4	T19 * Little marvel	55 – 60	8	JNKVV,Jabalpur
Pant matar 2	Early badger * IP3	55 – 60	6	GBPUAT, Pantnagar
Hisar harit		60	10	HAU, Hisar
Matar Ageta 6		50	6	PAU, Ludhiana
Mid season and Late group				
Bonneville	From USA	85	12(45%)*	IARI,New Delhi
Lincoln	From USA	85 -90	9-10 (45%)	IARI,New Delhi
Punjab 88 (p88)	Pusa 2 * Morassis 55	100	22.5	PAU,Ludhiana
Mithi phali		90 (edible podded)	11 -12	PAU,Ludhiana
JP 19		90 (edible podded)	10 -11	JNKVV,Jabalpur

Pea Varieties Resistant to Diseases and Insects

Disease/Insect Pest	Resistant Variety	Source
DISEASES		
Powdery Mildew (Erysiphe polygoni)	Jawahar Pea 83, JP4 (JM 6), PRS4, FC 1	JNKVV,Jabalpur
Fusarium Wilt (Fusarium oxysporum f. sp. Pisi)	Kalanagini, JP 179, Pusa Vipasha	JNKVV,Jabalpur, IARI, New Delhi
Rust (Uromyces fabae)	JP.Batri Brown 3 JP. Batri Brown 4	JNKVV, Jabalpur
Ascochyta Blight (Ascochyta pisi)	Kinnauri	Local Cultivar
Bean Yellow Mosaic Virus	Bonneville	IARI, New Delhi
INSECT PESTS		
Leaf Miner (Phytomyza atricornis)	LMR-4, LMR-10, LMR-20	HAU, Hisar
Bruchus (Callosobruchus chinensis)	JP 9, JP 179, JP Batri Brown 3, JP Batri Brown 4	JNKVV, Jabalpur
MULTIPLE RESISTANCE AND PEST RESISTANCE		
Highly Resistant to Powdery Mildew	JP 179	JNKVV, Jabalpur
Resistant to Bruchus & Powdery Mildew	JP 9	JNKVV, Jabalpur
Resistant to Fusarium Wilt	JP 501 A/2	JNKVV, Jabalpur
Resistant to Rust	JP Batri Brown 3&4	JNKVV, Jabalpur
Resistant to Rusts and Powdery Mildew	Arka Sampoorna, Arka Karthik	IIHR, Banglore

which is early maturing has wrinkled seeds. Most of the pea cultivars have been developed by hybridization between an Indian variety and an exotic variety. In pea there are also edible podded varieties in which the pods do not have sclerenchymatous membrane on inner pod walls and immature, very slow developing seeds wich are very small or rudimentary. These varieties with edible pods are known as Sugar snap pea (P. sativum var.macrocarpon) or Snow sugar or China pea (P. sativum saccharatum).

BREEDING FOR RESISTANCE TO DISEASES AND INSECT PESTS

In India, breeding for disease and pest resistance in pea was started at the JNKVV, Jabalpur about Two Decades Ago. Successful attempts were made to develop pea cultivars having resistance to a few important diseases, like Powdery mildew, Fusarium Wilt and Rust along with desired attributes, such as, maturity, yield of green pods, length of pods and seed quality (100 seed weight, wrinkled and seed colour). A few multiple disease resistant cultivars with insect resistance were also evolved. There were many sources of powdery mildew resistance, such as, P185, P388, P6585, P6587, Sel.1, Morassis-55, T-10, T -56, JP 501, and few others. The three important powdery mildew resistant cultivars are Jawahar pea 83, a mid- season garden pea developed from a double cross (Arkel $_x$ JP 829), $_x$ (46c $_x$ JP501). Jawahar pea 4 from a cross, Local yellow Batri x (6588 $_x$ 46c) and a high yielding mid- season variety PRS 4. Several exotic pea varieties, like Alaska, Early Gaint, Sylvia, Kelvedon Monarch and a few others as well as some Indian varieties, like T17, Selection 1, GC 66, GC 468, Lokar, Pusa vipasha, and the local varieties Kalanagini were found to be resistant to Fusarium Wilt when tested under epiphytotic conditions. However, wilt resistance varied at different locations due to race problem. Two races of Fusarium wilt have been reported. A Fusarium resistant source , JP 501 A/2, was identified at JNKVV, Jabalpur. It was also resistant to powdery mildew. The variety JP 179 was developed which is resistant to Fusarium wilt along with resistance to powdery mildew and tolerant to rust. Generally the Powdery mildew resistant varieties are susceptible to Rust.

However, the variety Arka Karthik developed at IIHR, Bangalore has combined resistance to rust and powdery mildew. Another variety of Snap pea, Arka sampoorna, is also resistant to rust and powdery mildew. There are also two pea lines, JB Batri 3 and JP Batri Brown 4, resistant to rust. However, both these lines are highly susceptible to powdery mildew. These two lines are being used in developing improved rust resistant cultivars with other desired attributes.

BREEDING FOR RESISTANCE TO INSECT PESTS

Breeding for resistance to leaf miner was undertaken at JNKVV, Jabalpur and HAU, Hisar. Sources of resistance to leaf miner were identified, such as, JP 179, JP 169-1, JP 747 and a few others at Jabalpur and LMR 4, LMR 10 and LMR 20 at Hisar. Improved cultivars having resistance to leaf miner have not been developed yet.

The two pea lines, JP 9 and JP 179 selected are resistant to Pea weevil, Bruchus. The crosses of Pisum fulvum with P.sativum hold promise for resistance to the pea seed weevil (Bruchus pisorum). A few lines with multiple resistance to diseases and pests were developed at Jabalpur. These multiple resistant lines are, JP 179- highly resistant to powdery mildew, resistant to Fusarium wilt, tolerant to rust and resistant to leaf miner and Bruchus, JP 9 resistant to Powdery mildew and Bruchus and JP Batri Brown 3 and JP Batri Brown 4- resistant to rusts and Bruchus. Attempts were made to combine pest resistance with multiple disease resistance for developing improved cultivar for commercial cultivation.

BREEDING FOR ABIOTIC STRESS

Breeding peas for cold resistance or cold hardiness by recurrent selection and resistance to water logging has been under taken. The “leafless” pea is tolerant to water logging.

BREEDING FOR HIGH PROTEIN AND SUGAR CONTENT

The wrinkled seed peas contain 26-33% protein content and in smooth seeds it is 23-31%. The inheritance of protein content is polygenically controlled, and mainly by recessive factors for high protein content. The varieties GC 195 and the local cultivar, Kinnauri have high soluble protein content due to the presence of a very high number of dominant genes.

BREEDING FOR PROCESSING QUALITIES

Dehydration, canning and freezing are the most common processing methods of peas. Large sized wrinkled and dark green peas like Arkel are suitable for dehydration. For canning, both round and wrinkled seeded varieties like T 19 and Bonneville can be used and for freezing wrinkled seeds.

FUTURE PROSPECTS

The area under field pea in India is likely to stagnate or shrink in future due to competition from irrigated wheat, and more remunerative pulses with wider consumers' preference. Field pea breeding programme are likely to be operated on a lower scale. However, vegetable peas are becoming increasingly attractive despite the fact that commercially acceptable cultivars are resistant to powdery mildew and rust. Therefore, breeding for resistance to these two diseases combined with emphasis on freezing and canning attributes should be encouraged. Arkel and Bonneville must get priority on the part of vegetable breeders as a challenge to them.

REFERANCES

Aghora, T.S., Mohan,N., Pal, A.B., Somkumar, R.G., Ganeshan, Girjija and Tiwari, R.B. 2002. Evolution of high yielding garden pea variety resistant to rust and powdery mildew. pp.47.

Blixt, S. 1974. The "Handbook of Genetics," Resistant to Plenum Press New York, 2:181-221.

Blixt, S. and Williams, J.T. 1982. Documentation of Genetic Resources: A Model ; Blixt,S. and Williams,J.T. (eds.), IBPGR, Secretariat, Rome

Chauhan, K.S and Mangal, J.L. 1993. Agro-techniques for legume vegetables, pp 483-501,In: K.L.Chadha and G.Kalloo(eds), " Advances in Horticulture", Vol.**5 :** Part 1, Malhotra Publishing house, New Delhi-110064, India

Daly, Doughas, Cameron, C., Kenneth, M. and Stevenson Dennis,W. 2001. Plant Systematics in the Age of Genomics. *Plant Physiology*, 127 : pp.1328-1333

Deshpande. S.S and Adsule R.N. 2005.Garden Pea., In: Handbook of vegetable Science. pp 433 – 441

Gritton, E.T. 1986. Pea Breeding In : M.J. Bassett (eds), "Breeding Vegetable Crops", AVI Publishing Co.Inc., Westport, Connecticut, U.S.A, pp.283-319

Hedley, C.L., Ambrose, M.J.1981. Designing ' leafless' plants for improving yields of the dried pea crop. *Adv. Agron.,* 34 : 225-277

Kalloo, G., 1993. Pea- *Pisum sativum* L. In, G.Kalloo and B.O. Bergh (eds), "Genetic Improvement of vegetable crops." Pergamon Press, Oxford and Newyork, pp.409-425.

Mercykutty, V.C., Kumar, H. and Srivastava,C.P.1990. Chromosome manipulation for protein improvement in pea (*Pisum sativum* L.,) *J.Genet.Breed.,*44:249

Mohan, N., Aghora, T.S., Somkuwar, R.G., Pal, A.B., Wani, Akella, Ganeshan Girija and Rawal, R.D. 2002. Evolution of snap pea resistant to powdery mildew and rust.pp.58. In : Abstracts of invited and Contributed papers ," Vegetables for sustainable food and nutritional security in the New Mellenium", International conference on vegetables, November 11-14-2002, Banglore.

Narsinghani, V.G. and Tiwari, Ambika. 1993. Improvement of Garden Pea. In: K.L. Chadha and G. Kalloo (eds), " Advances in Horticulture," Vol. **5** , Part 1, pp. 217-233; Malhotra Publishing House, New Delhi -110064, India,

Peter K.V. 1998. In: Genetics and Breeding of vegetables. pp 240 – 261.

Ram Hari Har. 1999. Garden Pea In: Vegetable Breeding Principles and Practices. pp. 220 – 227.

Swarup Vishnu. 2006. Pea. In: Vegetable Science and Technology. pp 456 – 469.

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