

**“MORPHOLOGICAL CHARACTERIZATION OF
LINSEED (*Linum usitatissimum* L.) GENOTYPES”**

M. Sc. (Ag.) Thesis

by

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**DEPARTMENT OF GENETICS AND PLANT BREEDING
COLLEGE OF AGRICULTURE
INDIRA GANDHI KRISHI VISHWAVIDYALAYA
RAIPUR (Chhattisgarh)**

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**“MORPHOLOGICAL CHARACTERIZATION OF
LINSEED (*Linum usitatissimum* L.) GENOTYPES”**

Thesis

Submitted to the

Indira Gandhi Krishi Vishwavidyalaya, Raipur

by

Swagatika Mohanty

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In

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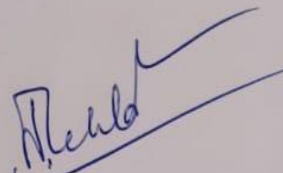
AUGUST, 2021

CERTIFICATE-I

This is to certify that the thesis entitled "**Morphological characterization of linseed (*Linum usitatissimum* L.) genotypes**" submitted in partial fulfillment of requirements for the degree of **Master of Science in Agriculture** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **Swagatika Mohanty** under our guidance and supervision. The subject of the thesis has been approved by the student's Advisory committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma or has been published/ published part has been fully acknowledged. All the assistance and help received during the course of the investigation have been duly acknowledged by her.

Date: 12/08/2021


Chairman

THESIS APPROVED BY THE STUDEN'S ADVISORY COMMITTEE

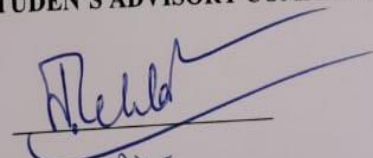
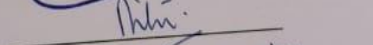
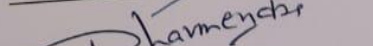
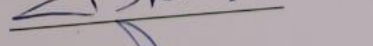
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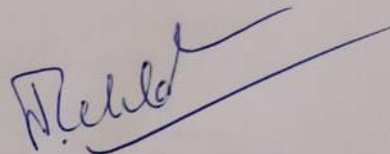
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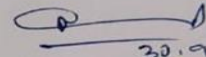
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Date: 30/09/2021

Name : Dr. Nandan Mehta

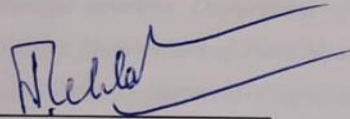
CERTIFICATE -II

This is to certify that the thesis entitled "**Morphological characterization of linseed (*Linum usitatissimum* L.) genotypes**" submitted by **Swagatika Mohanty** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfillment of the requirements for the degree of **Master of Science in Agriculture** in the **Department of Genetics and Plant Breeding** has been approved by the external evaluator and Student's Advisory Committee after oral examination, under the chairmanship of Head of Department / Dean (in case of out campii).


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Learning gives creativity. Creativity leads to thinking. Thinking provides knowledge. Knowledge makes you great.

Dr. A. P. J. Abdul Kalam

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Raipur

Date: 13.08.2021

Swagatika
SWAGATIKA MOHANTY

Department of Genetics and Plant Breeding

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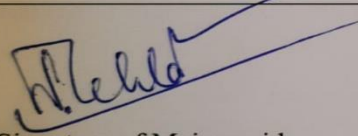
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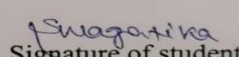
LIST OF ABBREVIATIONS

ABBREVIATIONS	DESCRIPTION
%	Per cent
DUS	Distinctiveness, uniformity and stability
°C	Degree Celsius
Cm	Centimeter
No.	Number
<i>viz.</i>	For example
ANOVA	Analysis of variance
d.f.	Degree of freedom
<i>et al.</i>	Coworkers and others
G	Gram
Ha	Hectares
Qt	Quintal
Fig.	Figure
S. no	Serial number
SD	Standard deviation
CD	Critical difference
<i>i.e.,</i>	that is
M	Meter
Mm	Millimeter
Approx.	Approximately
GCV	Genotypic coefficient of variation
PCV	Phenotypic coefficient of variation
r_g	Genotypic correlation coefficient
r_p	Phenotypic correlation coefficient
*	Significance at 5%
**	Significance at 1%

THESIS ABSTRACT

(a) Title of the thesis	: "Morphological characterisation of linseed (<i>Linum usitatissimum</i> L.) genotypes".
(b) Full name of the student	: Swagatika Mohanty
(c) Major subject	: Genetics and Plant Breeding
(d) Name and address of the major adviser	: Dr. Nandan Mehta , Principal scientist, AICRP on Linseed, IGKV, Raipur
(e) Degree to be awarded	: M.Sc. (Agriculture)


Signature of Major guide


Signature of student

Date: 12.8.2021


Signature of Head of the Department

ABSTRACT

The current study, entitled “**MORPHOLOGICAL CHARACTERISATION OF LINSEED (*Linum usitatissimum* L.) GENOTYPES**” was undertaken during *rabi* 2020-21 at the “Research cum Instructional farm, Department of Genetics and Plant Breeding, College of Agriculture, IGKV, Raipur, C.G.”. Materials used in the experiment consisted of twenty-six genotypes Including four check (RLC-92, RLC-143, RLC-148, RLC-151) released from AICRP on linseed IGKV, Raipur C.G. Observation on qualitative & quantitative traits had been noted on ten plant which were chosen randomly from each plot including replications. The traits were noted for eighteen qualitative and fifteen quantitative character viz., cotyledon shape. Anthocyanin colour of hypocotyl, stem anthocyanin colour, leaf colour, leaf anthocyanin colour, inflorescence shape, petal colour, petal aestivation, petal margin shape, petal margin folding, petal venation colour, sepal termination, sepal anthocyanin colour, capsule dehiscence, capsule shape and capsule shape of base. Quantitative character includes total height of plant, epicotyl branching, leaf length,

Diameter of open flower, capsule width, capsule/plant, seed length, seed width, capsule per plant, 1000 seed weight, seed weight per plant, length of flowering, number of days from seedlings to early yellow maturity, number of days from seedling to full maturity and seed yield/hectare. All the observations were studied using various morphological descriptor as per UPOV 2011(International union for the protection of new varieties of plants) & Flax Council of Canada and descriptor of IFDB-International Flax Database (2006), Project coordinating unit (Linseed) Kanpur, 2010.

According to the classification based on DUS descriptor, for cotyledon shape 9 (35%) genotypes were included in class of oval, 10 (38%) in class of elliptical and 7 (27%) in class of circular. Based on presence of anthocyanin colour in hypocotyl 18 (69%) genotypes have anthocyanin colour & only 8 (31%) genotypes donot have anthocyanin colour in their hypocotyl. Based on leaf colour 6 (23%) genotypes belonged to the category of light green, 13(50%) to the category of green and 7(27%) genotypes belonged to dark green category. Based on inflorescence shape thirteen (50%) belonged to class of branchy, six (23%) genotypes belonged to moderately branchy and seven (27%) genotypes fall in the class of compact. Based on petal colour one (4%) genotypes having violet coloured flower, four (15%) genotypes having violet blue colour, nine (35%) genotypes having light blue colour, eleven (42%) genotypes having blue coloured and only one (4%) genotype having white coloured flower. Based on petal aestivation ten (38%) genotypes belonged to twisted category, eight (31%) genotypes belonged to semi twisted and eight (31%) genotypes belonged to valvate category. Based on petal venation colour twenty (77%) genotypes belonged to class blue, five (19%) genotypes to class violet and one (4%) genotypes belonged to class white. Based on petal margin shape nine (35%) genotypes categorized that even, fourteen (54%) as crenate and three (11%) genotypes categorized as coarsely crenate. Based on petal margin folding seventeen (66%) genotypes belonged to plain category, four (15%) genotypes belonged to folded inward and five (19%) genotypes belonged to folded outward category. Based on reproductive organ position fourteen (54%) genotypes belonged to anthers surrounds stigma closely, seven (27%) genotypes belonged to anthers surrounds

stigma openly, four (15%) genotypes to stigma present below anthers and one (4%) genotype belonged to stigma above anthers category. Based on stigma colour seventeen (62%) genotypes fall under the category of white and nine (38%) genotypes fall under blue category. Based on style colour eighteen (69%) genotypes fall under the category of white and eight (31%) genotypes fall under blue category. Based on sepal termination fifteen (58%) genotypes belonged to class longitudinally acute and eleven (42%) genotypes belonged to acute category. Based on capsule shape twelve (46%) genotypes belonged to globular, six (23%) genotypes belonged to pressed and eight (31%) genotypes belonged to conical category. Based on capsule shape of base sixteen (62%) genotypes belonged to class circular base and ten (38%) genotypes belonged to class having heart shaped base.

Analysis of variance found to be significant for all the quantitative character. The variability can tapped and can be used for further development of variety. The highest yield was observed for the genotype RLC-184 (14.10 Qt.). High PCV as well as GCV was shown by number of capsule per plant. The magnitude of PCV was higher than GCV indicated the impact of environment on genotype.

The highest heritability was observed for the trait number of capsules per plant 96.71% followed by stem thickness 92.53%. the lowest heritability was observed in leaf length 36.08%. The genetic advance as percent of mean was found to be highest in number of capsules per plant. The lowest value was observed in leaf length 6.4%.

The strong significant and positive correlation between seed weight per plant and capsule per plant suggested that a high capsule per plant might indicate a higher seed yield. As a result, selection based on capsule per plant may be reliant on high seed yield for variety development.



थीसिस सार

(ए) थीसिस का शीर्षक	:" अलसी जीनोटाइप का रूपात्मक लक्षण वर्णन (लिनम यूसिटाटिसिमम एल.) "
(बी) छात्रा का पूरा नाम	: स्वागतिका मोहंती
(सी) प्रमुख विषय	: आनुवंशिकी और पादप प्रजनन
(डी) प्रमुख सलाहकार का नाम और पता	: डॉ नंदन मेहता, प्रमुख वैज्ञानिक ए.आई.सी.आर.पी. अलसी, आई.जी.के.वी., रायपुर
(ई) प्रदान की जाने वाली उपाधि	: एम. एस. सी. (कृषि)

प्रमुख सलाहकार के हस्ताक्षर

छात्रा के हस्ताक्षर

दिनांक: 12.8.2021

विभागाध्यक्ष के हस्ताक्षर

सार

वर्तमान अध्ययन, जिसका शीर्षक है "अलसी जीनोटाइप का रूपात्मक लक्षण वर्णन (लिनम यूसिटाटिसिमम एल.)" रबी 2020-21 के दौरान रिसर्च सह अनुदेशात्मक फार्म, आनुवंशिकी और पादप प्रजनन विभाग, कृषि कॉलेज, इं. गां. कृ. वि., रायपुर, छत्तीसगढ़ में जीनोटाइप्स का कार्य किया गया था। प्रयोग में प्रयुक्त सामग्री में छब्बीस जीनोटाइप शामिल थे, जिसमें चार चेक (RLC-92, RLC-143, RLC-148, RLC-151) शामिल थे, जो कि अखिल भारतीय समन्वित अनुसंधान परियोजना - अलसी इं. गां. कृ. वि., रायपुर पर गुणात्मक और मात्रात्मक लक्षणों का निरीक्षण दस पौधों पर नोट किया गया था। जिन्हें प्रतिकृति सहित प्रत्येक भूखंड से यादृच्छिक रूप से चुना गया था। लक्षणों को अठारह गुणात्मक और पंद्रह मात्रात्मक चरित्र नोट किया गया था। हाइपोकोटिल का आकार, हाइपोकोटिल का एंथोसाइनिन रंग, स्टेम एंथोसाइनिन रंग, पत्ती कारंग, पत्ती एंथोसाइनिन रंग, आकार, पुष्पदलविन्यास पंखुड़ी का रंग, पंखुड़ी एविडेंस, पंखुड़ी मार्जिन आकार, पंखुड़ी मार्जिन फोल्लिंग, पंखुड़ी वेशन रंग, सेपल टर्मिनेशन, सेपल एंथोसाइनिन रंग, कैप्सूल डेथॉसिन, कैप्सूल आकार और आधार का कैप्सूल आकार। मात्रात्मक चरित्र में पौधे की कुल ऊंचाई, एपिकोटाइल ब्रांचिंग, पत्ती की लंबाई, व्यास शामिल हैं। खुले फूल, कैप्सूल की चौड़ाई, कैप्सूल/पौधे, बीज की लंबाई, बीज की चौड़ाई, प्रति पौधे कैप्सूल, १००० बीज वजन, प्रति पौधे बीज वजन, फूलों की लंबाई, रोपण से प्रारंभिक पीले परिपक्वता तक के दिनों की संख्या, अंकुर से पूर्ण परिपक्वता और बीज

उपज/हेक्टेयर तक के दिनों की संख्या। यू.पी.ओ.वी. 2011 (पौधों की नई किस्मों की सुरक्षा के लिए अंतर्राष्ट्रीय संघ) और कनाडा की फ्लैक्स काउंसिल और आईएफडीबी-इंटरनेशनल सन डाटाबेस (2006), परियोजना समन्वय इकाई (अलसी) कानपुर, 2010 के वर्णनकर्ता के अनुसार विभिन्न रूपात्मक वर्णनकर्ता का उपयोग करके सभी टिप्पणियों का अध्ययन किया गया।

डीयूएस वर्णनकर्ता के आधार पर वर्गीकरण के अनुसार, कोटिलेडन आकार 9 (35%) जीनोटाइपको अंडाकार, 10 (38%) दीर्घ वृत्ताकार कक्षा में और 7 (27%) परिपत्र की कक्षा में शामिल किया गया था। हाइपोकोटायल 18 (69%) में एंथोसाइनिन रंग की उपस्थिति के आधार पर जीनोटाइपका एंथोसाइनिन रंग होता है और केवल 8 (31%) जीनोटाइपएस के हाइपोकोटिल में एंथोसाइनिन रंग नहीं होता है। पत्ती के रंग के आधार पर 6 (23%) जीनोटाइप हल्के हरे रंग की श्रेणी से संबंधित थे, 13(50%) हरे रंग की श्रेणी में और 7 (27%) जीनोटाइप डार्क ग्रीन श्रेणी के थे। पुष्पक्रम आकार आधार पर तेरह के (50%) शाखा के वर्ग के थे, छह (23%) जीनोटाइप मामूली शाखा और सात (27%) जीनोटाइप कॉम्पैक्ट की कक्षा में आते हैं। पंखुड़ी रंग एक के आधार पर (4%) बैंगनी रंग के फूल वाले जीनोटाइप, चार (15%) बैंगनी नीला रंग वाले जीनोटाइप, नौ (35%) जीनोटाइपका हल्का नीला रंग, ग्यारह (42%) जीनोटाइप नीले रंग का होता है और केवल एक (4%) जीनोटाइप जिसमें सफेद रंग का फूल पाया गया। पंखुड़ी पुष्पदलविन्यास आधार पर दस (38%) जीनोटाइप मुड़ श्रेणी के थे, आठ (31%) जीनोटाइप सेमी मुड़ और आठ (31%) जीनोटाइप वैल्वेट श्रेणी के थे। पंखुड़ी वेनेशन रंग आधार पर बीस के (77%) जीनोटाइप कक्षा नीले रंग के थे, पांच (19%) जीनोटाइप को बैंगनी वर्ग और एक (4%) जीनोटाइप वर्ग सफेद से संबंधित थे। पंखुड़ी मार्जिन आकार नौ के आधार पर (35%) जीनोटाइप वर्गीकृत कि थे यहां तक कि, चौदह (५४%)दंतीला के रूप में और तीन (11%) जीनोटाइप को मोटे क्रेनेट के रूप में वर्गीकृत किया गया है। पेटल मार्जिन फोल्डिंग के आधार पर सत्रह (66%) जीनोटाइप सादे श्रेणी के थे, चार (15%) जीनोटाइप अंदर की ओर मुड़े हुए थे और पांच (19%) जीनोटाइप फोल्डेड आउटवर्ड श्रेणी के थे। प्रजनन अंग की स्थिति के आधार पर चौदह (54%) जीनोटाइप परागकोश से संबंधित थे, स्टिग्मा को बारीकी से घेरते हैं, सात (27%) जीनोटाइप परागकोश से संबंधित होते हैं जो खुले तौर पर स्टिग्मा को घेरते हैं, चार (15%) जीनोटाइप्स को परागकोश के नीचे मौजूद स्टिग्मा और एक (4%) जीनो टाइप संबंधित होते हैं। परागकोष श्रेणी से ऊपर स्टिग्मा के लिए। स्टिग्मा रंग के आधार पर सत्रह (62%) जीनोटाइप सफेद की श्रेणी में आते हैं और नौ (38%) जीनोटाइप नीले रंग की श्रेणी में आते हैं। शैली के रंग के आधार पर अठारह (69 %) जीनोटाइप सफेद की श्रेणी में आते हैं और आठ (31%) जीनो टाइप नीले रंग की श्रेणी में आते हैं। सीपल टर्मिनेशन के आधार पर पंद्रह (58%) जीनोटाइप लंबे समय तक तीव्र वर्ग के थे और ग्यारह (42%) जीनोटाइप एक्यूट श्रेणी के

थे। कैप्सूल आकार के आधार पर बारह (46%) जीनोटाइप गोलाकार के थे, छह (23%) जीनोटाइप दबाए गए थे और आठ (31%) जीनोटाइप शंकाकार श्रेणी के थे। आधार के कैप्सूल आकार के आधार पर सोलह (62%) जीनोटाइप वर्ग वृत्ताकार आधार के थे और दस (38 %) जीनोटाइप दिल के आकार के आधार वाले वर्ग के थे।

विचरण का विश्लेषण सभी मात्रात्मक लक्षणों के लिए महत्वपूर्ण पाया गया। टी वह परिवर्तनशीलता में दोहन किया जा सकता है और विविधता के आगे विकास के लिए उपयोग किया जा सकता है। जीनोटाइप RLC-184 (14.10 कि.) के लिए उच्चतम उपज देखी गई। उच्च पीसीवी के साथ-साथ जीसीवी प्रति पौधे कैप्सूल की संख्या और प्रति हेक्टेयर बीज उपज द्वारा दिखाया गया था। पीसीवी का परिमाण जीसीवी से अधिक था जो जीनोटाइप पर पर्यावरण के प्रभाव को दर्शाता है।

प्रति पौधा कैप्सूल की विशेषता संख्या 96.71% के लिए उच्चतम आनुवंशिकता देखी गई, इसके बाद तने की मोटाई 92.53% थी। पत्ती की लंबाई 36.08% में सबसे कम आनुवंशिकता देखी गई। औसत के% के रूप में आनुवंशिक प्रगति प्रति पौधे कैप्सूल की संख्या में सबसे अधिक 68.62% पाई गई। पत्ती की लंबाई 6.4% में सबसे कम मूल्य देखा गया।

प्रति पौधे बीज वजन और प्रति पौधे बीज भार के बीच मजबूत महत्वपूर्ण और सकारात्मक सहसंबंध ने सुझाव दिया कि प्रति पौधे एक उच्च बीज वजन उच्च बीज उपज का संकेत दे सकता है। नतीजतन, प्रति पौधे बीज भार के आधार पर चयन विविधता के विकास के लिए उच्च बीज उपज पर निर्भर हो सकता है।

CHAPTER- I

INTRODUCTION

Linseed (*Linum usitatissimum* L.) $2n = 30$, is a valuable oilseed crop & belongs to the genus *Linum* of the Linaceae family, order Geraniales, with 300 species and 25 genera, and is the only species in the family that has economic value. It is also known as flax. The name *Linum* originated from Latin "thread" and the species name *Usitatissimum* is a Latin word meaning "most useful". Linseed is indigenous to regions includes western Mediterranean to India and in Fertile Crescent area it was first domesticated. It is cultivated as food and fibre crop in region of the world with temperate climate. Linseed which is also known as "Alsi" is one of the most significant oilseeds crops next to rapeseed and mustard in area as well as production.

According to (Richharia,1962) linseed has two center of origin South West Asia, particularly in India, on the basis of diversity of plant types. It is called as linseed when used as oilseed and called as flax fibre when it is used as fibre (Vaisey-Genser and Diane,2003). The genus has about 290 species in which only is *Linum usitatissimum* L. is of economic importance. Allaby *et al.* (2005) suggest that the cultivated species arise from a single domestication event from *L. bienne* also known as pale flax. The related wild species found in India are named as *L. perenne*, *L. strictrum*, *L. mysorensense*, *L. angustifolium* and *L. grandiflorum* and the character like annual habit, non-shattering of capsules are selected for first domestication. Linseed is highly efficient at self-fertilization (Fu 2011); however, it does occasionally result in 2% outcrossing due to insect activity (Dilman 1928). It is a long-day and self-pollinated crop that is grown in 34 countries throughout the world.

Linseed is an annual herbaceous plant that grows to a height of 90 to 120cm in light soil conditions and has a well-developed fibrous root system with multiple lateral roots. Fibre type are tall and less branched than seeded type. It has slender stalk and branches are normally concentrated at the top. Leaves are simple sessile lance shaped borne

alternate to the stalk. The flower borne on the stems growing from the branch tips having terminal raceme type inflorescence. Flowers having a long pedicel, five sepals, five petals of colour varying from different shades of blue to white and are bisexuals and having hypogynous type ovary. fruit of linseed is capsule of 5-9mm diameter which contains 8-10 seed of shiny surface and brown to golden yellow colour. Test weight of 1000seed grains varies from 4 to 9 gm.

Linseed, often known as flax (*Linum usitatissimum* L.), is a valuable crop for seed oil, stem fibre, and to a lesser extent, flour. Colour of linseed oil vary from colorless to pale yellow obtained from dried seed by pressing, sometimes by solvent extraction. Paints, inks, varnish, and other wood treatments, as well as soap, linoleum, putty and medications, can all be made with oil. Linoleum flooring, the most resilient type of sheet flooring, is a popular choice for today's modern world. Linoleum is a natural, environmentally beneficial flooring material made out of roughly 30% linseed oil. It's not only beautiful and long-lasting, but it's also good for the environment. Linoleum flooring is a type of flooring that is commonly referred to as linoleum. Linoleum flooring biodegradable and decomposes completely when discarded. Because of its present colours and performance, linoleum has become the flooring of choice in public buildings and private residences all over the world. Artist-designed inlays are becoming increasingly popular in the flooring business, thanks to linoleum's flexibility for water-jet cutting techniques. The flax fibre is highly useful raw material for textiles, thread/rope and packaging materials, while the straw and short fibre are used to make pulp for special papers such as cigarettes, bank notes and artwork, the straw and short fibre. The wooden component is used as bio-energy or litter in cow farming (Rowland, 1998).

Flaxseed is high in oil, protein, and fibre. Flaxseed comes in two different colours: brown and golden. Brown flax has a fat content of 41% and a protein content of 20%. 28 percent dietary fibre, 7.7% moisture, and 3.4 percent ash (the mineral-rich residue left behind after burning). As the oil content of the seed increases, the protein content of the seed falls. Omega 3 and Omega 6 fatty acids are found in the oil. linolenic acid, Eicosapentaenoic acid and Docosahexanoic acid (DHA). All three fatty acids have been shown to lower the risk of heart disease (Hurteau,2004). Recent studies suggest that Flax

seed is high in phytochemicals, including many antioxidants. Lignans are fiber-like substances that, in addition to fibre benefits also provide antioxidant protection due to their polyphenolic nature. It is perhaps our best source of lignans, When flaxseed is eaten, the lignans are activated by bacteria in the intestine, promote fertility, reduce premenopausal symptoms, and possibly help prevent breast cancer. It contains approx. 9.0g SFA, 18.4g MUFA, 67.8G PUFA per 100 g seeds. Surprisingly high amount of ALA allows this oil to oxidize rapidly so it is not recommended for eating purpose. Linseed oil is also high in tocopherols (alpha and gamma), vitamin K, and phytosterols. Linseed also contains anti-nutritional compounds such as “Mucins, cyanogenic glycosides (linamarin, linustatin and neo-linustatin), pyridoxine antagonist (linatine), trypsin inhibitors, phytoestrogens and phytic acid,” which can have a negative impact on quality of eggs and production performance in laying hens due to trypsin inhibitors, which reduce the efficiency of proteolytic (Klosterman *et al.*, 1967). To employ Flax oil in cooking where a high level of stability is required, Green and Marshall (Green, A. G. and D.R. Marshall, 1984) isolated mutants with as little as 1-3 percent -linolenic acid, a level regarded adequate for traditional edible oil uses with self-stability (Rowland, G. G., 1991). The Flax Council of Canada has assigned the label solin to flax cultivars with less than 5% ALA are suitable for food purposes.

On increasing demand of linseed day by day because of several benefits for health and industrial application it is need of the day to increase the potential of linseed production. As per the food and Agriculture Organization statistical data (FOASTAT,2018) currently the overall production of linseed in world is around 3.18million tones, with Canada (34%), Russia (15%) and China (13%) being the major producers. In world India stands 6th adding 13%and 5.5%to global linseed area and production respectively. India is the foremost growing country of linseed ranking 4th in area 3.20 lakh ha and production of 1.74 lakh tones followed by Kazakhstan, Russia and Canada. In India linseed production was 120666 MT whereas in terms of productivity India 671kg/ha (Anonymous, 2019-20) is far behind to Switzerland (2525kg/ha), Kyrgyzstan (225.7kg/ha), Tunisia (2142.5kg/ha) and France (1909.1kg/ha)

If we're talking about the state of Chhattisgarh, in terms of area and productivity, it is one of India's most major linseed-growing states. In the state, it's largely grown as a *rabi* crop. Though here temperature is high as compare to other state but in some district like Durg, Bilaspur, Kawardha, Raipur, Sarguja, Kanker where it has been grown successfully. Here normally it is grown as rainfed crop 63%and utera 25% and irrigated 17%. In Chhattisgarh linseed is being cultivated in 25790 ha area with a production of 640 tones & productivity of 248 kg/ha. (India stat 2018). The low productivity of linseed can be improved by using a high-quality seed programme. The reason of low productivity mainly lies on its cultivation on marginal and sub marginal land, rainfed soil facing moisture stress biotic stress like powdery mildew, Alternaria blight, different insect pest, and lack of follow up improved technique by the farmer. It is also a fact that the state having a short growing period for growth of flax varieties. All the flax genotypes grown at specifically Raipur condition due to short spell of winter are not performing well or not matching the growth parameters. So that an extensive hybridization programme was initiated at Raipur in AICRP on Linseed from 2012 where foreign flax varieties are crossed with RLC accession to get dual purpose genotypes at Raipur condition having short winter.

Large number of linseed varieties have been released from IGKV, AICRP on Linseed since 1967. In general, all IGKV cultivars have a higher degree of plant physical similarity, as well as a blue flower and a comparable growth pattern. Different varieties have unique characteristics which can be preferred for distinguishing them. This fact provides a crucial place for “DUS testing, varietal identification and verification (Keefe 1999)”. The requirement of unique and distinct in morphological character is the basis for providing a guideline or to prepare a map. The use of standard descriptors to describe the features of a crop species is useful for better germplasm utilisation and conservation (Diederichsen and Richards,2003). Morphological character also play role on the growth and development of plant in different habitats. Taking above facts into account Linseed genotypes were characterised in this research based on DUS guidelines or DUS descriptor as per UPOV 2011(International union for the protection of new varieties of plants) & Flax Council of Canada and descriptor of IFDB-International Flax Database (2006), Project coordinating unit (Linseed)Kanpur, 2010.

There is need to develop a suitable map for easy identification of linseed genotypes, the present investigation entitled as “**MORPHOLOGICAL CHARACTERISATION OF LINSEED (*Linum usitatissimum* L.) GENOTYPES**” was conducted at Research cum Instruction farm, Department of Genetics and Plant Breeding, IGKV, Raipur, C.G during *rabi* 2020-21 with following objectives.

1. To find out morphological differentiation among linseed genotypes according to DUS guidelines.
2. To characterize different linseed genotypes based on DUS guidelines.
3. To prepare a standard catalogue for differentiation among the genotypes on the basis of morphological distinctness.
4. To prepare a valuable guideline by taking together different DUS descriptors of Linseed which can be used as a future reference.

CHAPTER-II

REVIEW OF LITERATURE

Linseed crop is grown for various purposes like food fibre and industrial applications. The availability of a vast genotype for characterization and evaluation of data is very much important for understand the importance of the crop in agriculture. The development of new varieties suited to different environmental conditions is a continuous process by seeing the increasing demand it is very much important to increase the sustainable production of linseed. All the new varieties have to be registered under the PPVFR Act 2001 and it must satisfy the criteria of novelty, distinctness, uniformity and stability. Hence there is a need to develop a standard catalogue by taking the morphological character for easy identification of the variety.

The present investigations entitled as **“MORPHOLOGICAL CHARACTERISATION OF LINSEED (*Linum usitatissimum* L.) GENOTYPES”** is reviewed here under following heads-

2.1 Characterisation of linseed genotype following DUS guidelines.

2.2 Studies on genetic variability

2.2.1 Analysis of variance

2.2.2 Mean performances

2.2.3 Genotypic and phenotypic coefficient of variation

2.2.4 Heritability and genetic advance

2 2.5 Corelation analysis

2.1 Characterisation of linseed genotype following DUS guidelines.

Kerkhi *et al.* (2002) categorize the number of linseed germplasm into various categories by taking various specifying quantitative and morphological character which also include disease reactions.

Adugna *et al.* (2006) evaluated 60 genotypes of linseed having Ethiopian origin and classify into various cluster according to 10 morphological characters.

Dubey *et al.* (2006) estimated the germplasm of linseed by taking 10 agro morphological and quality character by utilizing KL-233 and Surbhi as a check. They assessed maximal variable for number of branches in each plant 9.85%.

Martin Pavelek *et al.* (2008) described the technique to differentiate linseed genotypes by using digital image analyser (digital image analysis version NIS element AR 2.30). Significant difference in floral morphology have been reported among the genotypes which provide information related to similarity and differences.

Sinha and Wagh (2013) reported that there is a vast morphological difference present in linseed germplasm. Characters like plant height, days to flowering, capsule size, seed size show variation among themselves. most important point is that 69.23% showed medium plant height, 76.92% showed medium days to maturity and all the seed are grouped under the category of medium and 69.23% lines falls under medium seed weight.

Janka Nozkova *et al.* (2014) at Russia reported the usefulness of image analysis software to determine the differences among linseed genotype on quantitative traits. seven traits were measured on whole seed and in longitudinal seed section 3 traits were measured. This resulted in traits reports on whole seed and cut seed differed significantly and categorize the seed into small or big.

Nagesh *et al.* (2015) at Ethiopia, centre of diversity classify one hundred ninety-eight Ethiopian local linseed accessions into various levels and patterns of diversity according to morphological character like days to flower initiation, days to maturity, branching pattern etc.

Worku *et al.* (2015) at Ethiopia evaluated 198 germplasm of linseed on the basis of oil content and morphological character. The standard collection include plant with both fibre and oilseed type. Result shows that oil content of standard grouping was evaluated, and percentage of oil was low as 30% than germplasm of other place. Days to flowering and days to maturity show distinctness and are highly heritable.

Dhirhi *et al.* (2016) At Raipur examined 150 linseed genotypes. DUS characterization of 150 diverse line including exotic and indigenous accessions of linseed, which were taken from AICRP on Linseed, Department of Genetics and Plant Breeding IGKV, Raipur (C.G.), India during Rabi 2014-15. Observations were recorded as per DUS, UPOV 2011. The morphological traits were evaluated as per Distinctiveness, Uniformity and Stability (DUS) guidelines. Yield contributing characters like plant height, time of flowering, capsule size, seed size and 1000 seed weight showed variation and most of the lines come under medium category as 79%, 43%, 52%, 77%, 43% respectively.

Bhajantari *et al.* (2017) at Raichur evaluated 13 genotypes collected from PC Unit Kanpur. The genotypes used for the study were 1) Jeevan, 2) Ruchi, 3) Pratapalsi 4) Parvati, 5) Meera, 6) Rashmi, 7) Shikha, 8) Nagarkot, 9) Gaurav, 10) JRF-1, 11) JRF-3, 12) JRF-4, 13) PCL-16-2. Observations were recorded as per DUS, UPOV 2011. The morphological traits were evaluated as per Distinctiveness, Uniformity and Stability (DUS) guidelines. Yield contributing characters like plant height, time of flowering, capsule size, seed size and 1000 seed weight showed variation and most of the lines come under medium category as 69.23% 76.92%, 53.84%, 100% and 69.23%, respectively. The results showed the range of characters which can be exploited in breeding lines appropriate for smallholder and commercial farmers in, producing a sustainable, secure, high-value crop meeting agricultural, economic and cultural needs.

Patial *et al.* (2018) at the exploratory farm of the Department of Crop Improvement, CSKHPKV, Palampur studied among 34 linseed genotype using 18 agro-morphological characteristics indicated by standard descriptor of DUS.UPOV-2011. Six genotype were viewed as obvious dependent on morphological qualities. Results revealed that sufficient

genetic variance was looked for all the characters inspected subject to various innate variability.

2.2 Studies on genetic variability

The scope of any crop improvement programme is depend on the genetic variability present and that if non-heritable type. In general, genetic diversity is a way of calculating degree of diversity between individual of that population. Parameter used for hereditary analysis like genetic advance, heritability, coefficient of variation for phenotypic and genotypic character help to classify it into heritable and non-heritable one. An idea of the amount of genetic genetic variability within linseed genotype is required to maintain and exploit the genotype as well as relationship among different accession provide a way for conservation purpose.

2.2.1 Analysis of variance

Mirza *et al.* 1996 evaluated thirty genotypes for yield and eight of its components at Oilseed Research centre, BARI, Gazipur. Analysis of variance resulted into significant differences among character like seed yield/plant (gm), harvest index (%), capsule per plant, days to flowering, plant height, but there is no significant difference in primary branches per plant and seed weight.

Mahto and Mahto (1998) nineteen genotype of linseed was evaluated by them and character such as seed yield per plant, number of capsule per plant, number of primary and secondary branches showing high genetic coefficient of variation was observed.

Adugna and Labuschangne (2004) evaluated sixty linsed accession predominantly from Ethiopia for eleven characters in a Randomized complete Block Design at University of free state, South Africa. They observed that mean square of combined analysis of variance in that two year were highly significant than others. Due to temperature differences between the glass house genotype X environment interaction occurs.

Awasthi and Rao (2005) at IGAU, twenty-nine accession of linseed were evaluated by them and showed that primary and secondary branches per plant, number

of capsules per plant and seed yield per plant showed high genotypic coefficient of variation.

Dubey *et al.* (2006) during rabi 2003-04 and 2004-05, examined 65 linseed germplasms in Kanpur for ten agro-morphological and qualitative traits using two checks, KL223 and Surabhi. The greatest difference was discovered in the number of branches in each plant. They discovered a lot of diversity across 10 characters when it came to the number of branches in each plant (9.85%) and the quantity of seed in each plant (7.44 %).

Kumari and Rao (2007) looked nearly ninety different linseed genotypes and discovered that seed output per plant had the most genotypic heterogeneity.

Tadesse *et al.* (2010) from Ethiopia investigated native linseed germplasms and found that while genotypic differences were non-significant for number of primary branches per plant, number of capsules per plant, number of seeds per capsule, seed yield per plant, biomass, and oil content (percent) in the combined analysis across multiple locations, genotypic differences were significant for number of primary branches per plant, number of capsules per plant, number of seeds per capsule, seed yield per plant, biomass, and oil content percent. Evaluations of genotypic and phenotypic coefficients of variability at the two sites revealed significant variability for the majority of the variables studied.

Reddy *et al.* (2013) During rabi, 2010-11, forty-eight linseed (*Linum usitatissimum* L.) accessions were evaluated at College of Agriculture, AICRP on Linseed, Nagpur for eleven polygenic traits to estimate the nature and extent of variability, heritability in the broad sense, and genetic advance. An analysis of variance found that all of the qualities a had significant differences.

Tyagi *et al.* (2014) studied character like plant height (cm), number of primary branches per plant, number of secondary branches per plant, leaf area, number of capsules per plant, number of seeds per capsules, stem diameter, and days to maturity biological yield per plant (g), seed yield per plant (g), seed yield per plot (g), test weight (g) and harvest index (%) were among the variables at Sardar Vallabh Bhai Patel

University of Agriculture & Technology in Meerut, Uttar Pradesh. The analysis of variance reported highly significant differences between the treatments for all characters.

Kanwar *et al.* (2014) investigated 36 linseed genotypes and found substantial genotypic and phenotypic coefficients of variation for seed yield, number of capsules per plant, biological yield (g), number primary branches per plant, and number secondary branches per plant.

Singh *et al.* (2015) examined 53 different linseed genotypes. They explained that the genotypic and phenotypic coefficients of variability showed significant variation for all of the quantitative features studied. The small difference between GCV and PCV indicates that environmental conditions have little impact on character expressions.

Choudhary *et al.* (2016) used a randomised block design with three replications to investigate the mean performance, variability, heritability, and genetic advance for seventeen morphological characters, as well as yield and quality, over six generations for linseed crosses grown in two zones with five genetically distinct accessions of linseed during rabi, 2013-2014. Characters such as plant height were found to be significant.

Shalini *et al.* (2016) during the *rabi* 2012-13 used a set of eight parents, Meera, Padmini, LMS-149-4, JLS-9, LMS-153-3, RLC-76, KL-221 and LC-185, and their 28 F1's, as well as check T-397, in a Randomized Complete Block Design with three replications at the experimental field area of the Linseed Research Scheme at Birsa Agricultural University, Kanke. For practically all of the traits, except days to maturity, analysis of variance indicated very significant variations among genotypes, showing the presence of variability among treatments, which is essential for any crop improvement effort.

Dhirhi and Mehta (2019) during *rabi*, 2014-2015 and 2015-2016, at the Department of Genetics and Plant Breeding, College of Agriculture, AICRP on Linseed, IGKV, Raipur, Chhattisgarh reported that "Analysis of variance for ten seed yield and yield attributing traits in linseed" found significant for character namely "days to 50% flowering, days to maturity days to maturity, plant height, number of primary branches per plant and seed yield per plant" for replication mean sum of square.

2.2.2 Mean performance-

Paul *et al.* (2017) at the Experimental Farm of the Department of Crop Improvement, CSK Himachal Pradesh Krishi Vishwavidyalaya, Palampur during *rabi* 2015-2016 genetic variability for various agro-morphological traits was studied in thirteen linseed genotypes. KL-285, KL-288, KL-289, KL-290, KL-293, KL-294, KL-295, KL-296, KL-297, KL-299, KL-300, KL-301, and KL-302 with three checks of Nagarkot, Baner, and Himani during the *rabi* 2015-16 KL-285 and KL-299 were shown to be statistically superior than the best check Baner for seed yield per plant based on mean performance.

Dhirhi and Mehta (2019) at Department of Genetics and Plant Breeding, College of Agriculture, AICRP on Linseed, IGKV, Raipur, Chhattisgarh Plant height (cm) ranged from 44.3 to 78 cm with an overall mean of 61.1cm during *rabi* 2014-2015 and 2015-2016, with the “minimum value found in Sabour Yellow Shekhar” and the “highest range found in Sabour Yellow T-397,” whereas seed yield per plant(g) ranged from 2.78 to 7.09 g with an overall mean of 4.5 g, with the “minimum value found in Neela X Chambal” and the “highest range found in RLC- 92.

2.3 Studies on Genetic parameters

2.3.1 Genotypic and phenotypic coefficient of variation

Malik and Singh (1995) found that the yield of seed in each plant, the number of capsules in each plant, and the yield of seed in each plot of six different genotypes of linseed have high genotypic variation, and that most of the traits are unaffected by the environment, as the heritability of all characters except the number of branches in each plant was higher.

Mahto and Rehman (1998), The genotypic coefficient was found to be high for the number of capsules per plant, seed yield per plant, number of major branches per plant, and 1000 seed weight by (g).

Payasi *et al.* (2000) at Sagar (M.P.), India during 1992-93 and 1993-94 evaluated eighty linseed genotypes (*Linum usitatissimum* L.) under four farming conditions for genetic variability analysis with regard to twelve quantitative characters. There were significant variances in all of the characters between the genotypes. For principal and secondary branches per plant, as well as capsules per plant, PCV was higher than GCV. This suggests that the environment has a masking impact on the phenotypic manifestation of these features. Seed yield per plant, seed yield per hectare (qt/ha), and days to bloom initiation all had higher GCV and PCV.

Ioan (2001) of the Podu-Iloaiei Agricultural Research Station in Romania investigated the phenotypic variability of morphological features and seed yields, finding that the genotypic contribution was larger for “plant height (cm), length of linseed fibre, and 1000 seed weight (g)”. The “number of capsules per plant and seed output per plant (g)” were greatly influenced by the various environmental conditions.

Singh *et al.* (2001) compared the differences in days to maturity, seed yield per plant, number of primary branches per plant, days to 50% flowering, and plant height across twenty linseed genotypes. The number of primary branches in each plant had a higher variance of phenotypic coefficient, but the days to 50% blooming, seed yield in each plant, and number of secondary branches in each plant had a higher variation of genotypic coefficient.

Jain and Rao (2003) according to them number of capsules per plant, yield of seed per plant, number of seed per capsule, and number of secondary branches per plant all displayed higher variation in phenotypic and genotypic coefficients.

Muhammad *et al.* (2003) at Oilseeds Research Institute, Faisalabad, Pakistan, studied eight linseed genotypes viz., “LS-95, LS-99, LS-72, LS-77, LS 77, LS-83, LS - 85, LS-49 and Chandni” in Randomized Complete Block Design with four replications. Observations were recorded on “plant height, number of branches per plant, number of capsules per plant, 1000-seed weight and seed yield per plant”. Highest seed yield per plant was observed for LS-77. LS-77 is maximum in “number of branches per plant, number of capsules per plant, 1000-seed weight.” Statistical measures of diversity like genotypic and phenotypic variances, GCV and PCV indicated that differences between

PCV and GCV were less than 1.85 for all the traits except number of branches per plant. This shows that less environmental influence in phenotypic variance development.

Awasthi and Rao (2005) studied variability for the following ten characters: “days to 50% flowering, days to maturity, plant height, number of primary and secondary branches per plant, number of capsules per plant, number of seeds per capsule, number of seeds per plant, 100-Seed weight, seed yield per plant” at the College of Agriculture, IGKV, Raipur (C.G.). High magnitude of genotypic coefficient of variation was observed for “seed yield per plant followed by number of capsules per plant, number of secondary branches per plant and number of primary branches per plant.

Kandil *et al.* (2012) In Pakistan, discovered that the variation of phenotypic and genotypic coefficient was higher for yield of seed per plant, length of fruiting zone, seed index, diameter of main stem, and number of capsules per plant, all of which appointed character variation essentially give to the total variability. Fiber, on the other hand, showed moderate to lower variation of genotypic and phenotypic coefficient.

Reddy *et al.* (2013) During rabi, 2010-11, forty-eight linseed (*Linum usitatissimum* L.) genotypes were examined for eleven polygenic variables to examine the nature, degree, and magnitude of variability, at College of Agriculture, AICRP on Linseed, Nagpur. Estimates of increased genotypic and phenotypic coefficients of variation (PCV) for parameters including number of branches per plant, number of capsules per plant, seed production per plant (g), seed yield per plot (g), omega-6 fatty acid, and secoisolariciresinol di-glucoside (SDG) fatty acid. For all of the qualities studied, there were less differences between GCV and PCV, implying that PCV had less of an impact.

Kanwar *et al.* (2014) investigated greater phenotypic and genotypic coefficients of variation for most traits at College of Agriculture, Raipur (C.G.). Days to flower initiation, days to 50% flowering, plant height (cm), 1000 seed weight (g), and number of seeds per capsule all had moderate PCV and GCV values.

Patel *et al.* (2015) discovered that number of capsules per plant had the highest variance of genotypic and phenotypic coefficient, followed by yield of seed per plant and weight of thousand seeds.

Upadhyay and Mehta (2019) at IGKV evaluated sixty-three linseed genotypes from AICRP. The highest GCV was estimated for number of capsules per plant followed by number of seeds per capsule, where as highest PCV was observed in number of seed per plant followed by number of capsules per plant.

2.3.2 Heritability and genetic advance-

The proportion of genotypic variance to phenotypic variance is referred to as heritability. Genetic advance is the improvement in mean genotypic value of selected plants over the base population following a single generation of selection, i.e., genetic advance is the shift in a population towards superior side under selection after a single generation of selection.

Payasi *et al.* (2000) at Sagar, (M.P.) studied for “fibre length, seed yield per plant, seed yield per hectare, and days to blossom commencement in linseed,” reported a greater estimate of heritability combined with a higher genetic advance as a percentage of mean.

Naik and Satpathy (2002) reported that all of the variables investigated had a high heritability estimate with the exception of the number of seeds per capsule. Only the number of major branches per plant, the number of capsules per plant, and the weight of 1000 seeds per plant had higher genetic advance values (g).

Akber *et al.* (2003) at Pakistan observed that 82%-89% heritability for height of plant, number of capsules in each plant, yield of seed in each plant, weight of thousand seed. Except for height of plant, all the characters were correlated significantly and positively with yield of seed.

Kant *et al.* (2005) in Kanpur, Higher heritability and modest genetic advance were seen as mean percent was observed for seed yield in each plant, number of capsules in each plant, and number of major branches in each plant, indicating that there is room for improvement through selection. For the other qualities, higher heritability accompanied by lesser genetic progress as a mean percent was reported, indicating that selection is not more effected for these characters.

Gauraha *et al.* (2011) conducted a field experiment at the Oilseed Research Area, Department of Plant Breeding and Genetics, College of Agriculture, IGKV, Raipur (C.G.) and found that “higher estimates of heritability coupled with higher genetic advance as percent of mean for number of primary branches per plant, number of secondary branches per plant, number of capsules per plant, number of seeds per plant”.

Vardhan and Rao (2012) studied thirty diverse genotypes under three environmental conditions viz., “rain-fed, irrigated and late sown for variability analysis with respect to yield and yield components in linseed showed highest genotypic coefficient of variation under all the three environments was shown by seed yield per plant.” “High heritability was detected for days to maturity under irrigated conditions, as well as for seed yield per plant under rainfed and irrigated conditions.” For “1000-seed weight under irrigated condition,” there was a high heritability accompanied by a strong genetic advance.

Pali and Mehta (2013) reported number of seed in each plant, number of seeds in each capsule, number of capsules in each plant, number of secondary branches, yield of seed in each plant, and weight of hundred seed all had higher genetic advance and heritability, whereas number of primary branches in each plant had average heritability.

Rajanna *et al.* (2014) at Main Agricultural Research Station, UAS, Raichur used ten linseed genotypes viz., PCL-45, LCK-1101, RLC-133, BAU13-09, SLS- 87, RL-10193, NDL-2010-1-27, PKDL-133, LMS-2010-1-27 AND NL-97-26 and four checks viz., Padmini (Zonal check), T-397 (National check) and Two local checks (NL-115 and S-36) and the experiment was conducted in Randomized Complete Block Design with three replications. The genotypes listed above came from Kanpur's Project Coordination Unit. At the time of maturity, data were collected on plant height (cm), technical plant height (cm), days to 50% flowering, days to maturity, number of capsules per plant, number of seeds per capsule, 1000 seed weight (g), and seed yield per plant (g), with the intention that 1000 seed weight (g) and seed yield per plant (g) showed that “the higher values of heritability coupled with higher genetic advance”.

Kumara *et al.* (2015) at the experimental farm of the Department of Crop Improvement, CSKHPKV, Palampur, (H.P.) India, during rabi 2014-15, genotypes of

linseed (*Linum usitatissimum* L.) were evaluated; heritability and genetic progress are important selection factors, and selection accomplishment is a reflection of selection to response. Heritability estimates combined with genetic progress are usually more useful in determining genetic gain under selection than heritability estimates alone. “Higher heritability along with higher genetic progress as a percentage of mean were reported for seed yield per plant (g), biological yield per plant (g), and harvest index (percent),” indicating additive gene action.

Dash *et al.* (2016) in Odisha, discovered that the environment has a greater impact on the number of primary branches in each plant, the number of capsules in each plant, and the production of seed in each plant. The main significance of non-additive gene action was suggested by modest heritability along with moderate genetic improvements for weight of thousand grains.

Paul and Kumari (2018) at the Experimental Farm of the Department of Crop Improvement, CSK Himachal Pradesh Krishi Vishwavidyalaya Palampur, (H.P.) India, was studied that “the seed yield per plot (g) showed high assumed genetic advance as percentage of mean”. On the basis of present investigation “high heritability coupled with high genetic advance was recorded for seed yield per plot (g)”.

2.4 Studies on correlation analysis

The study of correlation is a cover for understanding the relationship between high heritable character and economic character, but measurement of correlation does not take into account the dependency of one variable on the other. Furthermore, simple correlation cannot distinguish between the direct effect of each component on yield and the indirect contribution of other components due to their relationship.

Akber *et.al* (2003) estimated seventeen linseed genotypes exhibit strong significant differences. The number of pods in each plant, the number of branches in each plant, and the number of seeds in each pod all have a positive and substantial relationship with seed yield. The direct contribution of the number of seeds in each pod has a stronger correlation and comes after the number of seeds in each pod and the number of pods in each plant.

Tadesse *et al.* (2009) at research farm of Sinana, Agricultural Research Center, Ethiopia, they reported that at Sinana, “seed yield per plot (g) showed a positive and highly significant association with plant height (0.401), thousand seed weight (0.326), seed yield per plant (g) (0.380), harvest index (percentage) (0.480), biomass (0.490), and oil content (0.407) at the phenotypic level.”

Ottai *et al.* (2011) at Genetics and Cytology Dept., National Research Center, Dokki, Giza, Egypt Studied the highest values for number of capsules per plants in the first, second and third season, respectively. During the first and second seasons, the second sowing date was the best, as it observed greater values of seed yield per plant for the genotypes under study. Straw yield per plant (g) was found to have a positive and substantial link with biological yield per plant (g), seed yield per plant (g), number of capsules per plant, technical plant length (cm), and plant height(cm), and between seed yield per plant (g) and number of capsules per plant, length of the fruiting zone (cm), technical plant length (cm), and plant height (cm), as well as between biological yield per plant (g) and length of the fruiting zone (cm) and plant height (cm), Considering the relationship between the number of capsules per plant and the technical plant length (cm) and plant height (cm), as well as the relationship between both plant height (cm) and technical plant length (cm) (cm). Out of all the trait combinations tested, non-significant negative correlation coefficients were found in 10 pairs. Each factor's component of seed yield changes is calculated separately and together.

Gauraha *et al.* (2011a) at Oilseed Research Area, Department of Plant Breeding and Genetics, College of Agriculture, IGKV, Raipur, (C.G.), concluded that although the genotypic and phenotypic correlation coefficients between distinct traits were comparable in direction, the genotypic correlation was larger in magnitude than the phenotypic correlations. “Seed yield was positively related to variables including number of seeds per plant, number of capsules per plant, number of secondary branches per plant, 1000 seed weight (g), plant height (cm), number of primary branches per plant, and days to maturity,” according to the study.

Kumar *et al.* (2013) at AICRP on Linseed, IGKV, Raipur (C.G.). During Rabi 2007-08, the experiment was set up in a Randomized Complete Block Design with three

replications. “At both the phenotypic and genotypic levels, seed yield had the highest significant positive correlation with biological yield (g) and number of capsules per plant, whereas days to maturity had a significant positive correlation with seed yield at both levels, whereas number of primary branches per plant had a significant positive correlation at the genotypic level only. The number of seeds per capsule, on the other hand, revealed a strong phenotypic association with seed output, but a highly significant genotypic association with seed yield. This indicates that “seed yield per plant had significant positive correlation with days to maturity, number of primary branches per plant, number of capsules per plant”.

Paul *et al.* (2015) at Palampur to determine the connection and genetic diversity, 16 genotypes of linseed were used. The coefficient of correlation revealed that in order to boost seed yield, direct selection of plants based on three characteristics, such as “plant height, seeds in each capsule, and capsules in each plant that have the most phenotypic and genotypic association” would be effective.

Choudhary *et al.* (2017) at the Field Experimentation Centre, Department of genetics and plant breeding, Agricultural Institute Naini, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, (U.P.) studied 21 genotypes of linseed which were obtained from Initial Varietal Trial (Rainfed) of AICRP on Linseed, Kanpur, “Seed yield per hectare exhibits a significant and positive correlation both at genotypic and phenotypic level with plant stand per net plot, number of capsules per plant, test weight, harvest index, and number of primary branches per plant,” according to the results of the Randomized Complete Block Design experiment. As a result, direct selection for these attributes would be most successful in improving performance of Linseed.

Ankit *et al.* (2019) at Crop Research Centre SVPUA&T Meerut (UP) used forty different genotypes of linseed obtained from the Project Coordinating Unit (Linseed), CSAUA&T, Kanpur during Rabi 2016-17 and studied that “Seed yield per plant displayed highly significant and positive association with days to 50% flowering, capsules per plant, biological yield (g), harvest index (percent), plant height, and seeds per capsule.”

It was discovered that by enhancing these qualities, grain yield may be increased through selection.

Hussain and Goyal (2021) investigated 85 linseed accessions and observed that seed yield per plant had a significant and positive correlation with number of capsule per plant, biological yield /plant. Hence improvement in these characters seed yield can be increased.

CHAPTER-III

MATERIALS AND METHOD

The present study entitled as “**MORPHOLOGICAL CHARACTERISATION OF LINSEED (*Linum usitatissimum* L.) GENOTYPES**” was carried out in *rabi* 2020-21. The details of the materials and methodologies applied for the study as well as observation recorded during the study described shortly in this chapter.

3.1 Geographical situation

The research conducted at Research cum Instruction farm IGKV Raipur, C.G. Raipur is in the southern part of the state having 21°16’N latitude 81°31’E longitude including an altitude of 289.56m above mean sea level.

3.2 Climate

Climatic condition found at Raipur is sub-tropical. Rainfall nearly about 120-140cm annually received out of which nearly 7-8% received during the *rabi* season. The pattern of rainfall varies greatly from year to year. Monsoon comes nearly mid to end of June and withdraw by the end of September. During the whole crop growth period climate was favourable which help in establishing a good crop stand, but rainfall during the yellow maturity stage increase the crop maturity duration. The data related weekly rainfall minimum and maximum temperature relative humidity, bright sunshine hours of whole crop growing period have been provided in fig.3.1

3.3 Experimental site

In *rabi* season field trials are conducted during 2020-21. The linseed genotypes are collected from All India Coordinated Research Project (AICRP) on linseed, Department of Genetics and Plant Breeding college of Agriculture, Raipur, to characterize the phenotypic character based on DUS guidelines. All the recommended package of practices are carried out to raise good stand of crops.

3.4 Experimental materials-

The biological materials used during the study comprises of twenty-six linseed genotypes collected from All India Coordinated Research Project (AICRP) on linseed, Department of Genetics and Plant Breeding currently functioning research cum Instructional farm college of Agriculture, Raipur. by using these 26 lines which include check RLC-92, RLC143, RLC-148, RLC-153 the morphological traits are characterized.

3.5 Experimental Design-

The experiment is carried out in Randomized Complete Block Design with three replications during *rabi* 2020-21. All the twenty-six genotypes were sown on 11th November 2020 in plot of 4m x 4m with row to row spacing of 30cm and plant to plant spacing of 10cm. Ten healthy competitive plant selected randomly from each plot for taking observation.

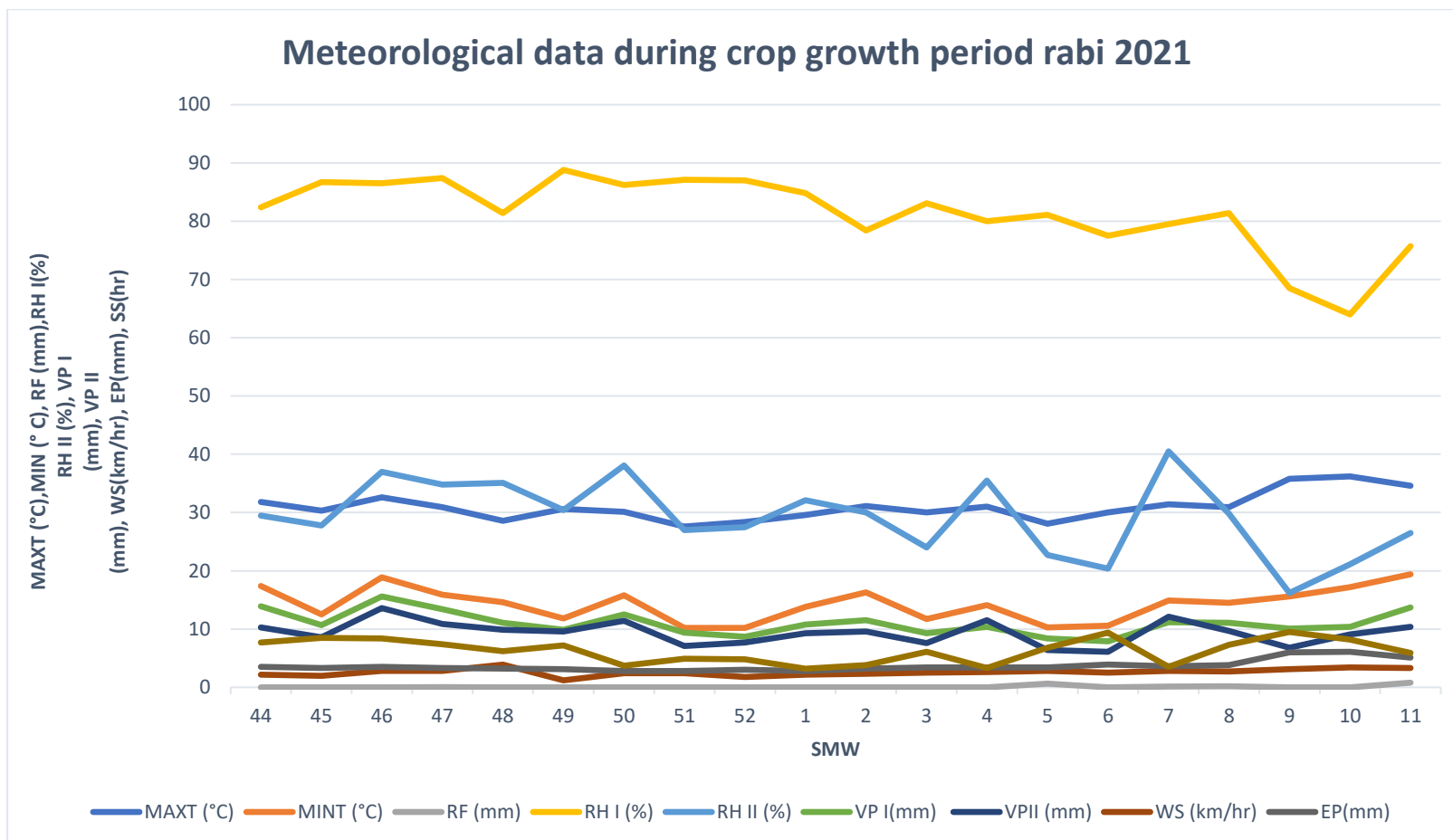


Fig.3.1 Meterological observation during crop growth period *rabi* (2020-21)

Table 3.1: Experimental materials used in the current research

S.no	Genotype	Parentage	Source
1	R-7	SELECTION OF NO.55	AICRP on linseed Department of Genetics and plant Breeding Raipur, C. G
2	R-552	No.55XR-67	AICRP on linseed Department of Genetics and plant Breeding Raipur, C. G
3	KIRAN	AFGAN-0/R/1	AICRP on linseed Department of Genetics and plant Breeding Raipur, C. G
4	KARTHIKA	KIRAN X LCK88062	AICRP on linseed Department of Genetics and plant Breeding Raipur, C. G
5	IA-32	KIRAN X RLC- 29	AICRP on linseed Department of Genetics and plant Breeding Raipur, C. G
6	RLC-92	JEEVAN X LCK 9209	AICRP on linseed Department of Genetics and plant Breeding Raipur, C. G
7	RLC-133	(NL-14 X Acc926) X LCK 9313	AICRP on linseed Department of Genetics and plant Breeding Raipur, C. G
8	RLC-138	R-552 X POLF-22	AICRP on linseed Department of Genetics and plant Breeding Raipur, C.G
9	RLC-143	LCK88062 X T397	AICRP on linseed Department of Genetics and plant Breeding Raipur, C.G
10	RLC-148	SIKO X KIRAN	AICRP on linseed Department of Genetics and plant Breeding Raipur, C.G
11	RLC-153	LCK88062XEC-1424	AICRP on linseed Department of Genetics and plant Breeding Raipur, C.G
12	RLC-161	AYOGI X GS 234	AICRP on linseed Department of Genetics and plant Breeding Raipur, C.G
13	RLC-164	POLF 22 X JRF 5	AICRP on linseed Department of Genetics and plant Breeding Raipur, C.G
14	RLC-167	T 397 X POLF 22	AICRP on linseed Department of Genetics and plant Breeding Raipur, C.G
15	RLC-171	POLF 22 X JRF 5	AICRP on linseed Department of Genetics and plant Breeding Raipur, C.G
16	RLC-172	GS 234 X R-552	AICRP on linseed Department of Genetics and plant Breeding Raipur, C.G
17	RLC-175	RLC-92 X LCK 88062	AICRP on linseed Department of Genetics and plant Breeding Raipur, C.G
18	RLC-176	POLF 22 X RLC 92	AICRP on linseed Department of Genetics and plant Breeding Raipur, C.G
19	RLC-181	SHEKHAR X RLC-95	AICRP on linseed Department of Genetics and plant Breeding Raipur, C.G
20	RLC-183	SHEKHAR X RLC-95	AICRP on linseed Department of Genetics and plant Breeding Raipur, C.G
21	RLC-184	GS-234 X TL-150	AICRP on linseed Department of Genetics and plant Breeding Raipur, C.G
22	RLC-185	DEEPIKA X JLS-9	AICRP on linseed Department of Genetics and plant Breeding Raipur, C.G

Table 3.1: Experimental materials used in the current research contd...

23	RLC-186	DEEPIKA X RLC-128	AICRP on linseed Department of Genetics and plant Breeding Raipur, C. G
24	RLC-187	AYOGI X T-397	AICRP on linseed Department of Genetics and plant Breeding Raipur, C.G
25	RFC-2019-1	POLF 34XRLC-92	AICRP on linseed Department of Genetics and plant Breeding Raipur, C.G
26	RFC-2019-2	POLF 22 X AYOGI	AICRP on linseed Department of Genetics and plant Breeding Raipur, C.G

3.6 METHODOLOGY

3.6.1 Observations to be recorded: -

In the present research observation on phenotypic characters are based on “National guidelines for distinctness, uniformity, and stability in linseed, India” published as per the catalogue on linseed germplasm, DUS descriptor as per UPOV 2011(International union for the protection of new varieties of plants) & Flax Council of Canada and descriptor of IFDB-International Flax Database (2006), Project coordinating unit (Linseed) Kanpur, 2010. Characters were recorded for the experiment as follows –

Morphological traits

- | | |
|----------------------------------|---------------------------------|
| 1. Cotyledon shape | 16. Sepal anthocyanin colour |
| 2. Stem anthocyanin colour | 17. Reproductive organ position |
| 3. Stem- total plant length(mm) | 18. Stigma colour |
| 4. Stem epicotyl branching | 19. Style colour |
| 5. Stem thickness (mm) | 20. Capsule- shape |
| 6. Leaf length (mm) | 21. Capsule- shape of base |
| 7. Leaf colour | 22. Capsule width (mm) |
| 8. Leaf anthocyanin colour | 23. Capsule dehiscence |
| 9. Inflorescence shape | 24. No of capsule per plant |
| 10. Diameter of open flower (mm) | 25. Seed length (mm) |
| 11. Petal colour | 26. Seed width (mm) |
| 12. Petal aestivation | 27. 1000 seed weight |
| 13. Petal margin shape | 28. Seed -weight per plant |

14. Petal venation colour

29. Seed yield/ha

15. Sepal termination

Biological features

1.Length of flowering

2. Number of days from seedling to early yellow maturity.

3. Number of days from seedling to full maturity.

Following techniques are adopted for recording observations: -

3.6.1.1 Total plant height (mm)-

It is measured from base of the plant up to the tip of the main branch, measured in millimeter.

3.6.1.2 Number of epicotyl branches-

Well-developed plant were selected and branches are counted from the base after full maturity of the plant.

3.6.1.3 Stem thickness(mm)-

Well-developed undamaged plant were selected and thickness of main stem was measured after full maturity.

3.6.1.4 Length of flowering-

Length of flowering is observed from the day with 1st flower up to the day when flowering ends.

3.6.1.5 Days from seedling to full maturity-

It was calculated from seed after germination up to 10% of its plant reaches full maturity that the capsule shows brown colour.

3.6.1.6 Weight of 1000 seeds (g)-

Ten well developed plant were selected and from which seeds were collected and counted. It is measured in gm.

3.6.1.7 Seed length and width(mm)-

Well-developed seed was collected from 10 selected plants, and it was measured in millimeter.

3.6.1.8 Number of capsule /plant-

Ten plants were selected and average capsule per plant was calculated.

3.6.1.9 Seed yield per plant (g) -

Seed weight of well developed seed from the population was taken and yield was calculated in quintals per hectare.

Table 3.2: DUS (Distinctness, Uniformity and Stability) descriptor for linseed as per UPOV 2011(International union for the protection of new varieties of plants) and Flax Council of Canada and descriptor of IFDB-International Flax Database (2006), Project coordinating unit (Linseed)Kanpur, 2010

S.N	Characters	Class or sage
1	Cotyledon shape	Oval Circled Elliptical
2	Anthocyanin colour of hypocotyl	Present Absent
3	Total plant length	Extremely Short <310mm Short 310-500mm Medium 500-700mm Long->700mm
4	Epicotyl branching	One stem Multi stem
5	Stem thickness	Thin <3mm

		Medium 3-6mm Thick >6mm
6	Leaf length	Short <20mm Medium 20-30mm Long >30mm
7	Leaf colour	Light green Green Dark green
8	Leaf anthocyanin colour	Present Absent
9	Inflorescence shape	Branchy Moderately branchy Compact
10	Diameter of open flower	Large >20mm Medium 15-20mm Small <15mm
11	Petal colour	Blue Light blue Violet blue Violet White
12	Petal aestivations	Twisted Semi twisted Valvate
13	Petal margin shape	Even Crenate Coarsely crenate
14	Petal margin folding	Plain Folded inward Folded outward
15	Petal venation colour	White Violet Blue
16	Sepal termination	Longitudinally acute Acute Short acute
17	Sepal anthocyanin colour	Present Absent
18	Reproductive organ position	Anther surrounds stigma closely Anther surrounds stigma openly Stigma above anther

		Stigma below anther
19	Stigma colour	White Blue
20	Style colour	White Blue
21	Capsule shape	Pressed Globular Conical
22	Capsule shape of base	Circular Heart shaped
23	Capsule width	Narrow <6mm Medium-6-7mm Wide >7mm
24	Capsule dehiscence	Semi dehiscent Non dehiscent
25	No. of capsule per plant	Low <50 Medium 50-70 High > 70
26	Seed length	Low <4mm Medium -4-5.5mm Long >5.5mm
27	Seed width	Narrow<2.5 Medium 2.5-3.5mm Wide >3.5mm
28	1000 seed weight	Very low <4gm Low 4-5g Medium 5-7 g High >8g
29	Seed weight per plant	Very low <1g Low 1-2.5g Medium 2.5-3.5g High >3.5g

3.6.2 Statistical analysis –

The analysis of the statistical data was carried out under following points that are analysis of variance, range standard deviation, genotypic & phenotypic coefficient of variation, heritability, genetic advance & correlation analysis among the quantitative character recorded.

3.6.2.1 Analysis of variance

The diverse traits are brought together to analyze the variability usually relevant to Randomized Complete Block Design with the formulae suggested by “Panse and Sukhatme” in 1967. The linear statistical model for RCBD is as given below-

$$Y_{ij} = \mu + a_i + b_j + e_{ij}$$

Where,

Y_{ij} = Yield of j^{th} genotype in i^{th} replication.

μ = General mean.

a_i = Effect of i^{th} replication.

b_j = Effect of j^{th} genotype.

e_{ij} = Uncontrolled variation associated with i^{th} replication and j^{th} genotype

Table 3.3: Analysis of variance for Randomized Complete Block Design

S. no	Source of Variation	Degree of freedom	Sum of square	Mean sum of square	‘F’ Calculated
1	Replications	r-1	SSR	MSR	RMS/EMS
2	Treatment	g-1	SST	MSG	GMS/EMS
3	Error	(r-1) (g-1)	SSE	MSE	
4	Total	rg-1	TSS		

Where,

r = Number of replications

g =Number of genotypes

SSR = Sum of squares of replication

SSG = Sum of squares of treatment

SSE = Sum of squares of error

MSR= Mean sum of squares of replication

GMT= Mean sum of squares of treatment

MSE= Mean sum of squares of Error

3.6.2.2 Assessment of variability

The mean values were calculated for quantitative traits to calculate variability parameter viz., range, mean, standard deviation and coefficient of variation.

3.6.2.2.1 Range

The lower and higher value of character determines its range, which is expressed as follows:

$$\text{Range} = \text{highest value} - \text{lowest value}$$

3.6.2.2.2 Mean

The average of recorded observations was calculated as follow.

$$\bar{X} = \sum \frac{X_i}{n}$$

Where,

ΣX_i = Summation of all the observations

n = Total number of observations

3.6.2.2.3 Standard Deviation

It is defined as the positive square-root of the arithmetic mean of the square of the deviations of the given observation from their arithmetic mean and calculated as:

$$SD = \sqrt{\frac{\sum d^2}{N}}$$

Where,

SD= Standard deviation

N= Total number of observations

3.6.2.2.4 Coefficient of variation (%)

The coefficient of variation is obtained by dividing the standard deviation by the mean and expressed in percentage. It is unit free. According “Burton” 1952 coefficient of variations is calculated as:

$$CV(\%) = \frac{SD}{X} \times 100$$

Where,

CV= coefficient of variation

SD = Standard deviation of Sample

X = Mean of sample

3.6.2.3 Genetic parameter

3.6.2.3.1 Phenotypic and Genotypic coefficient of variation

Estimation of genotypic and phenotypic coefficient of variation was calculated as suggested by Burton (1952). The phenotypic and genotypic components of variance were computed according to formulae given by Lush (1940).

According to Siva Subramanian and Madhava Menon (1973) the value of GCV and PCV were divided into low moderate and high category.

Category	Range
Low	<10%
Medium	10-20%
High	>20%

However, genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) in percentage were calculated according to following formula;

$$\sigma^2 = \frac{Mt - Me}{r}$$

Where,

σ^2g = Genotypic variance,

Mt = Treatment mean sum of square,

Me = Error mean sum of square (σ^2e)

a. Phenotypic coefficient of variation (PCV)

$$\sigma^2p = \sigma^2g + \sigma^2e$$

$$PCV = \frac{\sigma^p}{\bar{x}} \times 100$$

Where,

σ^2p & σ^p = Phenotypic variance and its standard deviation,

σ^2g & σ^g = Genotypic variance and its standard deviation,

σ^2e = Environmental variance,

x = General mean.

b. Genotypic coefficient of variation (GCV)

$$GCV = \frac{\sigma^g}{\bar{x}} \times 100$$

3.6.2.3.2 Heritability and genetic advance

Heritability (Broad sense) was calculated based on the ratio of genotypic variance to the phenotypic variance and was expressed in percentage (Hanson *et al.*, 1956)

$$\text{Heritability } h^2 (\text{bs}) (\%) = \sigma^2_g / \sigma^2_p \times 100$$

Where,

$h^2 (\text{bs})$ = Heritability in broad sense

σ^2_g = Genotypic variance

σ^2_p = Phenotypic variance

According to Robinson (1966) the broad sense heritability estimates were classified as low, moderate and high as follows:

0 - 50 % = Low

51 - 70% = Moderate, and

> 70% = High

3.6.2.3.3 Genetic advance

It is defined as the difference between the selected lines' mean genotypic value and the parental population's mean genotypic value. The predicted genetic advance denotes a change in a population's genetic makeup in the direction of an exclusive region under selective pressure next to single generation of selection. “Johnson et al. (1955a)” proposed a method for estimating the estimated genetic advance or gain under selection.

$$\text{Genetic advance (GA)} = h^2_{(\text{bs})} \times K \times \sigma_p$$

Where,

$h^2_{(\text{bs})}$ = Heritability in broad sense

σ_p = Phenotypic standard deviation of the original population

K = Selection intensity at 5% = 2.06 suggested by “Allard ”

3.6.2.3.4 Genetic advance as percent of mean

GA was reported as percentage of mean and it was calculated as follows:

$$\text{Genetic advance as percentage of mean} = (GA / \bar{x}) \times 100$$

Where,

GA = Genetic advance

$\bar{x}$ = Population mean.

The genetic advance as mean % was categories as low <10%, moderate 10-20%, high >20% as according to Johnson *et. al*, Falconor and Mackey (1996).

3.6.2.4 Association analysis

The genotypic and phenotypic correlation coefficients were estimated between the component characters for the entire environment under studied (Singh and Chaudhary, 1979).

The component of genotypic co-variance between two characters, as well as the component of phenotypic co-variance, were calculated in the same manner as the component of variance. The following co-variance was used to assess the phenotypic and genotypic connection between the two traits.

1.Genotypic Corelation coefficient between character x and y

$$r_{xy(g)} = \frac{Cov(g)X.Y}{\sqrt{\sigma^2(g)X \times \sigma^2(g)Y}}$$

Where,

$r_{xy(g)}$ = Genotypic correlation coefficient between x and y

$Cov_{(g)} xy$ = Genotypic covariance between x and y

$\sigma^2_{x(g)}$ = Genotypic variance of character x

$\sigma^2_{y(g)}$ = Genotypic variance of character y

2. Phenotypic Corelation coefficient between character x and y

$$r_{xy} (g) = \frac{Cov (p)X.Y}{\sqrt{\sigma^2(p)X \times \sigma^2(p)Y}}$$

Where,

$r_{xy} (p)$ = Phenotypic correlation coefficient between x and y

$Cov (p) xy$ = Phenotypic covariance between x and y

$\sigma^2x (p)$ = Phenotypic variance of character x

$\sigma^2y (p)$ = Phenotypic variance of character y

CHAPTER-IV

RESULTS AND DISCUSSION

The present study entitled as “**MORPHOLOGICAL CHARACTERISATION OF LINSEED (*Linum usitatissimum* L.) GENOTYPES**” was conducted in *rabi* 2020-21 with main objective to study the morphological differences among the linseed genotype which include both released varieties and pipeline varieties by combining different DUS guidelines and analyse the variation among different genotype and also to find the association in different traits among the genotype of linseed. The experiment was conducted at Research cum Instruction farm, IGKV, Raipur by using Randomized Complete Block Design with three replications in which twenty-six linseed genotypes including four check varieties (RLC-92, RLC-143, RLC-148, RLC-151). Ten well grown plants have been selected from each plot randomly. The data were recorded for morphological characterisation as per the different DUS guidelines *i.e.* UPOV 2011(International union for the protection of new varieties of plants) and Flax Council of Canada as well as descriptor of IFDB-International Flax Database (2006) and Project coordinating unit (Linseed) Kanpur, 2010. Results are obtained and presented under the following heads-

- 4.1 Listing morphological differences according to DUS guidelines.
- 4.2 Analysis of variance
- 4.3 Range and mean performances
- 4.4 Coefficient of variation for genotypic and phenotypic characters
- 4.5 Heritability and genetic advance
- 4.6 Association analysis for seed yield and its attributing traits

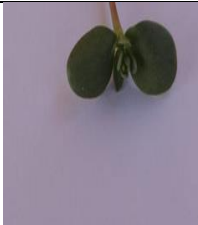
4.1 Listing morphological differences according to DUS guidelines for different character

The data were noted for qualitative character such as cotyledon shape, anthocyanin colour of hypocotyl, leaf colour, inflorescence shape, petal colour, petal aestivation, petal venation colour, petal margin shape, petal margin folding, reproductive organ position, stigma colour, style colour, sepal termination, sepal anthocyanin colour, shape of capsule and shape of capsule base

4.1.1 Cotyledon shape

Shape of cotyledon were scored after 10-12 days of germination. Based on cotyledon shape the genotypes were grouped into three classes such as circular, oval and elliptical. Out of 26 genotype 9 (35%) genotypes were included in class of oval, 10 (38%) in class of elliptical and 7 (27%) in class of circular.

Table 4.1: Classification of linseed Genotypes according to cotyledon shape

NAME OF VARIETY	R-7	R-552	KIRAN	KARTIKA	IA-32	RLC-92
PHOTOGRAPH						
CLASS	OVAL	CIRCULAR	ELLIPTICAL	ELLIPTICAL	ELLIPTICAL	OVAL

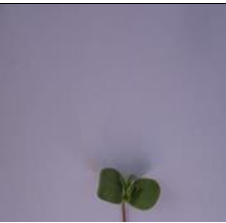
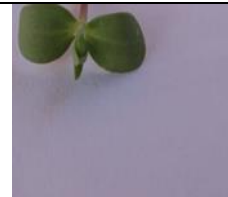
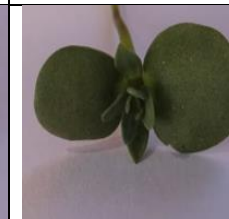
NAME OF VARIETY	RLC-133	RLC-138	RLC-143	RLC-148	RLC-153	RLC-161
PHOTOGRAPH						
CLASS	OVAL	OVAL	ELLIPTICAL	CIRCULAR	ELLIPTICAL	OVAL

Table 4.1: Classification of linseed Genotypes according to cotyledon shape contd...

NAME OF VARIETY	RLC-164	RLC-167	RLC-171	RLC-172	RLC-175	RLC-176
PHOTOGRAPH						
CLASS	ELLIPTICAL	OVAL	CIRCULAR	OVAL	ELLIPTICAL	ELLIPTICAL

NAME OF VARIETY	RLC-181	RLC-183	RLC-184	RLC-185	RLC-186	RLC-187
PHOTOGRAPH						
CLASS	OVAL	CIRCULAR	CIRCULAR	OVAL	ELLIPTICAL	ELLIPTICAL

NAME OF VARIETY	RFC-19-1	RFC-19-2
PHOTOGRAPH		
CLASS	CIRCULAR	CIRCULAR

4.1.2 Anthocyanin colour of hypocotyl

Anthocyanin colour of hypocotyl were recorded during recording the shape of cotyledon after 10-12 days of germination whether the anthocyanin colour present or absent. Out of 26 genotype mentioned above it was found that 18 (69%) genotype had anthocyanin colour and only 8 (31%) genotype don't possessed anthocyanin colour in their hypocotyl .

Table 4.2: Classification of linseed genotypes according to anthocyanin colour of hypocotyl

NAME OF VARIETY	R-7	R-552	KIRAN	KARTIKA	IA-32	RLC-92
PHOTOGRAPH						
CLASS	PRESENT	ABSENT	PRESENT	PRESENT	PRESENT	ABSENT

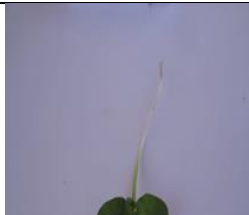
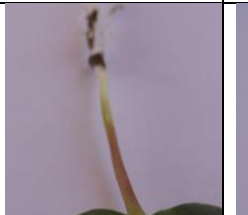
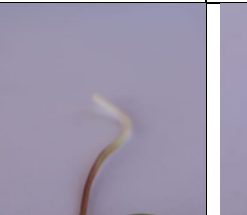
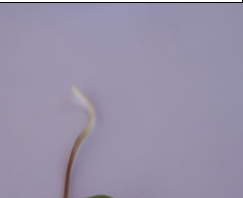
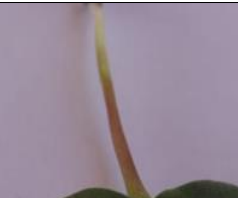
NAME OF VARIETY	RLC-133	RLC-138	RLC-143	RLC-148	RLC-153	RLC-161
PHOTOGRAPH						
CLASS	ABSENT	PRESENT	ABSENT	PRESENT	PRESENT	PRESENT

Table 4.2: Classification of linseed genotypes according to anthocyanin colour of hypocotyl contd...

NAME OF VARIETY	RLC-164	RLC-167	RLC-171	RLC-172	RLC-175	RLC-176
PHOTOGRAPH						
CLASS	ABSENT	ABSENT	PRESENT	PRESENT	PRESENT	PRESENT

NAME OF VARIETY	RLC-181	RLC-183	RLC-184	RLC-185	RLC-186	RLC-187
PHOTOGRAPH						
CLASS	PRESENT	PRESENT	PRESENT	ABSENT	PRESENT	ABSENT

NAME OF VARIETY	RFC-19-1	RFC-19-2
PHOTOGRAPH		
CLASS	PRESENT	PRESENT

4.1.3 Leaf colour

The data for leaf colour were taken in vegetative stage. Based on colour of leaf genotypes are divided into three class such as light green, green and dark green. out of 26 genotypes 6 (23%) genotypes belonged to the category of light green, 13(50%) to the category of green and 7 (27%) genotypes belonged to dark green category.

Table 4.3: Classification of linseed genotype according to leaf colour

NAME OF VARIETY	R-7	R-552	KIRAN	KARTIKA	IA-32	RLC-92
PHOTOGRAPH						
CLASS	DARK GREEN	GREEN	LIGHT GREEN	GREEN	GREEN	DARK GREEN

NAME OF VARIETY	RLC-133	RLC-138	RLC-143	RLC-148	RLC-153	RLC-161
PHOTOGRAPH						
CLASS	LIGHT GREEN	GREEN	GREEN	LIGHT GREEN	GREEN	LIGHT GREEN

Table 4.3: Classification of linseed genotype according to leaf colour contd...

NAME OF VARIETY	RLC-164	RLC-167	RLC-171	RLC-172	RLC-175	RLC-176
PHOTOGRAPH						
CLASS	GREEN	GREEN	DARK GREEN	LIGHT GREEN	GREEN	DARK GREEN

NAME OF VARIETY	RLC-181	RLC-183	RLC-184	RLC-185	RLC-186	RLC-187
PHOTOGRAPH						
CLASS	DARK GREEN	LIGHT GREEN	DARK GREEN	DARK GREEN	GREEN	GREEN

NAME OF VARIETY	RFC-19-1	RFC-19-2
PHOTOGRAPH		
CLASS	GREEN	GREEN

4.1.4 Inflorescence shape

For scoring inflorescence shape typical well grown undamaged plants selected from the middle of the plot. The data scored after full maturity so that the pattern of inflorescence can be easily identified. All the genotypes are classified into three categories such as branchy, moderately branchy and compact. out of twenty-six genotypes, thirteen (50%) belonged to class of branchy, six (23%) genotypes belonged to moderately branchy and seven (27%) genotypes belonged to the class of compact.

Table 4.4: Classification of linseed genotype according to inflorescence shape

NAME OF VARIETY	R-7	R-552	KIRAN	KARTHIKA	IA-32	RLC-92
PHOTOGRAPH						
CLASS	BRANCHY	COMPACT	MODERATELY BRANCHY	BRANCHY	BRANCHY	BRANCHY

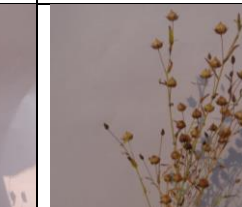
NAME OF VARIETY	RLC-133	RLC-138	RLC-143	RLC-148	RLC-153	RLC-161
PHOTOGRAPH						
CLASS	BRANCHY	MODERATELY BRANCHY	COMPACT	BRANCHY	BRANCHY	BRANCHY

Table 4.4: Classification of linseed genotype according to inflorescence shape contd...

NAME OF VARIETY	RLC-164	RLC-167	RLC-171	RLC-172	RLC-175	RLC-176
PHOTOGRAPH						
CLASS	MODERATELY BRANCHY	BRANCHY	COMPACT	BRANCHY	BRANCHY	BRANCHY

NAME OF VARIETY	RLC-181	RLC-183	RLC-184	RLC-185	RLC-186	RLC-187
PHOTOGRAPH						
CLASS	MODERATELY BRANCHY	COMPACT	BRANCHY	MODERATELY BRANCHY	COMPACT	COMPACT

NAME OF VARIETY	RFC-19-1	RFC-19-2
PHOTOGRAPH		
CLASS	COMPACT	MODERATELY BRANCHY

4.1.5 Petal colour

The data were recorded in full bloom stage by visual observation. Petal colour were grouped into five categories such as violet, violet blue, blue, tinge blue and white. Out of twenty-six genotypes, one (4%) genotypes having violet colour flower, four (15%) genotypes having violet blue colour, nine (35%) genotype having light blue colour , eleven(42%) genotypes having blue colour and only one (4%) genotype having white colour flower found.

Table 4.5: Classification of linseed genotypes according to petal colour

NAME OF VARIETY	R-7	R-552	KIRAN	KARTIKA	IA-32	RLC-92
PHOTOGRAPH						
CLASS	VIOLET BLUE	VIOLET BLUE	VIOLET	BLUE	BLUE	LIGHT BLUE

NAME OF VARIETY	RLC-133	RLC-138	RLC-143	RLC-148	RLC-153	RLC-161
PHOTOGRAPH						
CLASS	WHITE	BLUE	LIGHT BLUE	LIGHT BLUE	LIGHT BLUE	LIGHT BLUE

Table 4.5: Classification of linseed genotypes according to petal colour contd...

NAME OF VARIETY	RLC-164	RLC-167	RLC-171	RLC-172	RLC-175	RLC-176
PHOTOGRAPH						
CLASS	LIGHT BLUE	LIGHT BLUE	BLUE	LIGHT BLUE	VIOLET BLUE	BLUE PETAL

NAME OF VARIETY	RLC-181	RLC-183	RLC-184	RLC-185	RLC-186	RLC-187
PHOTOGRAPH						
CLASS	BLUE	VIOLET BLUE	BLUE	BLUE	BLUE	BLUE

NAME OF VARIETY	RFC-19-1	RFC-19-2
PHOTOGRAPH		
CLASS	LIGHT BLUE	BLUE

4.1.6 Petal aestivation

Flower aestivation was recorded as an arrangement of petal. According to the arrangement it was classified as twisted, semi twisted and valvate aestivations. Out of twenty-six genotypes ten (38%) genotypes belonged to twisted category, eight (31%) genotypes belonged to semi twisted and eight (31%) genotypes belonged to valvate category.

Table 4.6: Classification of linseed genotypes according to petal aestivation

NAME OF VARIETY	R-7	R-552	KIRAN	KARTIKA	IA-32	RLC-92
PHOTOGRAPH						
CLASS	SEMI TWISTED	SEMI TWISTED	TWISTED	TWISTED	SEMI TWISTED	SEMI TWISTED

NAME OF VARIETY	RLC-133	RLC-138	RLC-143	RLC-148	RLC-153	RLC-161
PHOTOGRAPH						
CLASS	VALVATE	TWISTED	SEMI TWISTED	TWISTED	VALVATE	VALVATE

NAME OF VARIETY	RLC-164	RLC-167	RLC-171	RLC-172	RLC-175	RLC-176
PHOTOGRAPH						
CLASS	VALVATE	VALVATE	SEMI TWISTED	TWISTED	TWISTED	VALVATE

NAME OF VARIETY	RLC-181	RLC-183	RLC-184	RLC-185	RLC-186	RLC-187
PHOTOGRAPH						
CLASS	TWISTED	TWISTED	VALVATE	VALVATE	TWISTED	SEMI TWISTED

NAME OF VARIETY	RFC-19-1	RFC-19-2
PHOTOGRAPH		
CLASS	TWISTED	SEMI TWISTED

4.1.7 Petal venation colour

Petal venation colour was divided into three class such as blue violet and white. Out of twenty-six genotypes twenty (77%) genotypes belonged to class blue, five (19%) genotypes to class violet and one (4%) genotypes belonged to class white.

Table 4.7 Classification of linseed genotype according to venation colour

NAME OF VARIETY	R-7	R-552	KIRAN	KARTIKA	IA-32	RLC-92
PHOTOGRAPH						
CLASS	VIOLET	VIOLET	VIOLET	BLUE	BLUE	BLUE

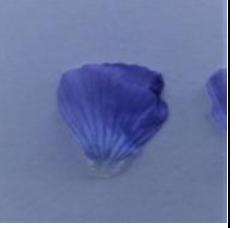
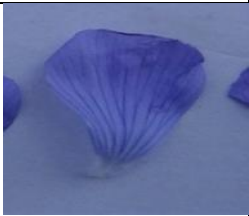
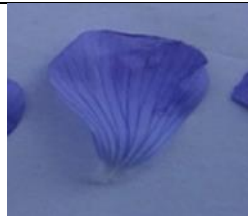
NAME OF VARIETY	RLC-133	RLC-138	RLC-143	RLC-148	RLC-153	RLC-161
PHOTOGRAPH						
CLASS	WHITE	BLUE	BLUE	BLUE	BLUE	BLUE

Table 4.7 Classification of linseed genotype according to venation colour contd...

NAME OF VARIETY	RLC-164	RLC-167	RLC-171	RLC-172	RLC-175	RLC-176
PHOTOGRAPH						
CLASS	BLUE	BLUE	BLUE	BLUE	VIOLET	BLUE

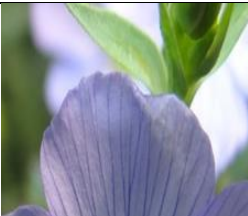
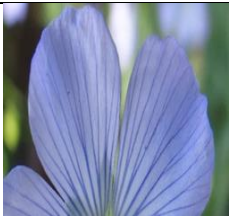
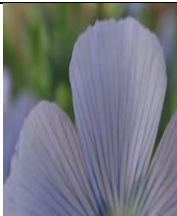
NAME OF VARIETY	RLC-181	RLC-183	RLC-184	RLC-185	RLC-186	RLC-187
PHOTOGRAPH						
CLASS	BLUE	VILOET	BLUE	BLUE	BLUE	BLUE

NAME OF VARIETY	RFC-19-1	RFC-19-2
PHOTOGRAPH		
CLASS	BLUE	BLUE

4.1.8 Petal margin shape

For the evaluation of petal margin shape, typical undamaged flowers were selected. The evaluation was realized in the morning after flower opens to the final shape. From a selected flower all the petals are evaluated. According to the shape it was classified into even, crenate and coarsely crenate. Out of twenty-six genotypes nine (35%) genotypes categorized that even, fourteen (54%) as crenate and three (11%) genotypes categorized as coarsely crenate.

Table 4.8: Classification of linseed genotypes according to petal margin shape

NAME OF VARIETY	R-7	R-552	KIRAN	KARTIKA	IA-32	RLC-92
PHOTOGRAPH						
CLASS	COARSELY CRENATE	CRENATE	CRENATE	EVEN	CRENATE	CRENATE

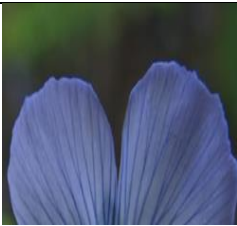
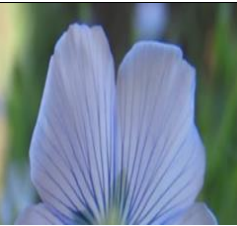
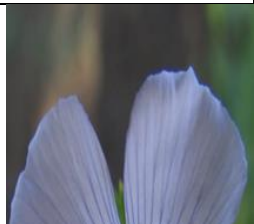
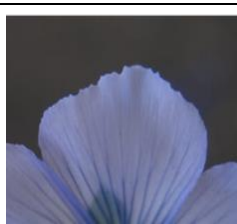
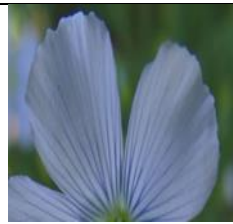
NAME OF VARIETY	RLC-133	RLC-138	RLC-143	RLC-148	RLC-153	RLC-161
PHOTOGRAPH						
CLASS	COARSELY CRENATE	CRENATE	CRENATE	CRENATE	EVEN	CRENATE

Table 4.8: Classification of linseed genotypes according to petal margin shape contd...

NAME OF VARIETY	RLC-164	RLC-167	RLC-171	RLC-172	RLC-175	RLC-176
PHOTOGRAPH						
CLASS	CRENATE	EVEN	CRENATE	EVEN	COARSELY CRENATE	CRENATE

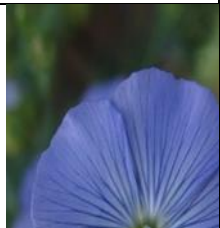
NAME OF VARIETY	RLC-181	RLC-183	RLC-184	RLC-185	RLC-186	RLC-187
PHOTOGRAPH						
CLASS	EVEN	CRENATE	EVEN	EVEN	EVEN	CRENATE

NAME OF VARIETY	RFC-19-1	RFC-19-2
PHOTOGRAPH		
CLASS	CRENATE	EVEN

4.1.9 Petal margin folding

For the evaluation flowers were grown on primary lateral branches are taken. The evaluation was realized in the morning after flower opens to the final shape. According to margin folding of petals the genotypes were classified as plain, folded inward and folded out ward. Out of twenty-six genotypes seventeen (66%) genotypes belonged to plain category, four (15%) genotypes belonged to folded inward and five (19%) genotypes belonged to folded outward category.

Table 4.9: Classification of linseed genotypes according to petal margin folding

NAME OF VARIETY	R-7	R-552	KIRAN	KARTIKA	IA-32	RLC-92
PHOTOGRAPH						
CLASS	FOLDED INWARD	PLAIN	FOLDED INWARD	PLAIN	PLAIN	PLAIN

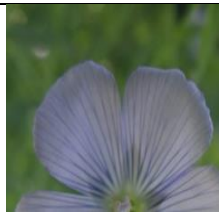
NAME OF VARIETY	RLC-133	RLC-138	RLC-143	RLC-148	RLC-153	RLC-161
PHOTOGRAPH						
CLASS	FOLDED INWARD	PLAIN	PLAIN	FOLDED INWARD	PLAIN	PLAIN

Table 4.9: Classification of linseed genotypes according to petal margin folding contd...

NAME OF VARIETY	RLC-164	RLC-167	RLC-171	RLC-172	RLC-175	RLC-176
PHOTOGRAPH						
CLASS	FOLDED OUTWARD	PLAIN	PLAIN	FOLDED OUTWARD	FOLDED OUTWARD	PLAIN

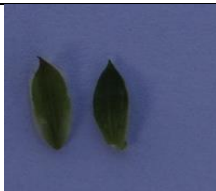
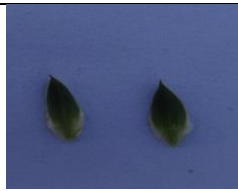
NAME OF VARIETY	RLC-181	RLC-183	RLC-184	RLC-185	RLC-186	RLC-187
PHOTOGRAPH						
CLASS	FOLDED OUTWARD	PLAIN	PLAIN	PLAIN	PLAIN	PLAIN

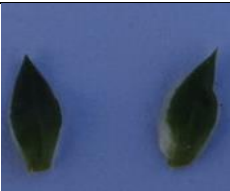
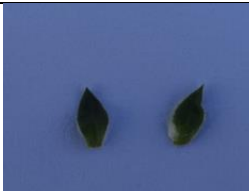
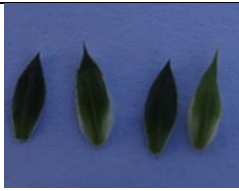
NAME OF VARIETY	RFC-19-1	RFC-19-2
PHOTOGRAPH		
CLASS	FOLDED OUTWARD	PLAIN

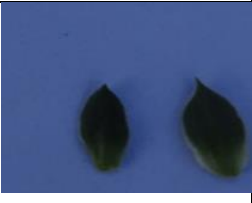
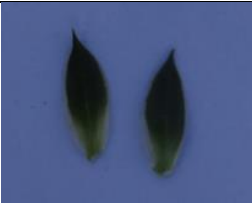
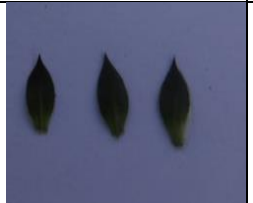
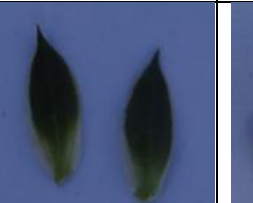
4.1.10 Sepal termination and sepal anthocyanin colour

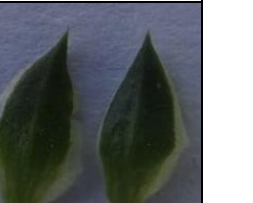
The data were scored in fully open flower in full blooming stage. According to the sepal the whole genotypes were classified in to two categories such as longitudinally acute and acute. Out of twenty-six genotype fifteen (58%) genotypes belonged to class longitudinally acute and eleven (42%) genotypes belonged to acute category. Sepal anthocyanin colour was not found in any of the genotypes.

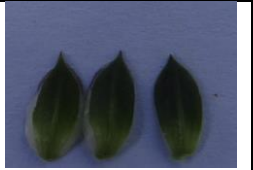
Table 4.10: Classification of linseed genotypes according to Sepal termination and sepal anthocyanin colour

NAME OF VARIETY	R-7	R-552	KIRAN	KARTIKA	IA-32	RLC-92
PHOTOGRAPH						
CLASS	LONGITUDINALLY ACUTE, ABSENT	LONGITUDINALLY ACUTE, ABSENT	LONGITUDINALLY ACUTE, ABSENT	LONGITUDINALLY ACUTE, ABSENT	ACUTE, ABSENT	LONGITUDINALLY ACUTE, ABSENT

NAME OF VARIETY	RLC-133	RLC-138	RLC-143	RLC-148	RLC-153	RLC-161
PHOTOGRAPH						
CLASS	LONGITUDINALLY ACUTE, ABSENT	ACUTE, ABSENT	ACUTE, ABSENT	LONGITUDINALLY ACUTE, ABSENT	LONGITUDINALLY ACUTE, ABSENT	LONGITUDINALLY ACUTE, ABSENT

NAME OF VARIETY	RLC-164	RLC-167	RLC-171	RLC-172	RLC-175	RLC-176
PHOTOGRAPH						
CLASS	ACUTE, ABSENT	LONGITUDINALLY ACUTE, ABSENT	ACUTE, ABSENT	LONGITUDINALLY ACUTE, ABSENT	ACUTE, ABSENT	LONGITUDINALLY ACUTE, ABSENT

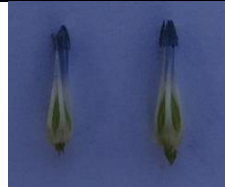
NAME OF VARIETY	RLC-181	RLC-183	RLC-184	RLC-185	RLC-186	RLC-187
PHOTOGRAPH						
CLASS	ACUTE, ABSENT	ACUTE, ABSENT	ACUTE, ABSENT	LONGITUDINALLY ACUTE, ABSENT	ACUTE, ABSENT	ACUTE, ABSENT

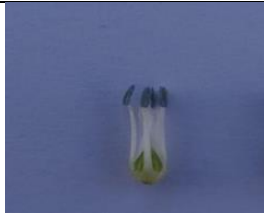
NAME OF VARIETY	RFC-19-1	RFC-19-2
PHOTOGRAPH		
CLASS	LONGITUDINALLY ACUTE, ABSENT	LONGITUDINALLY ACUTE, ABSENT

4.1.11 Reproductive organ position

Reproductive organ position were recorded during peak flowering period. For the observation to recorded healthy flowers were selected and examined closely. According to the position all the genotypes were classified into four categories such as- anther surround stigma closely, anthers surround stigma openly, stigma below anthers and stigma above anthers. Out of twenty-six genotypes fourteen (54%) genotypes belonged to anthers surrounds stigma closely, seven (27%) genotypes belonged to anthers surrounds stigma openly, four (15%) genotypes to stigma present below anthers and one (4%) genotype belonged to stigma above anthers category.

Table 4.11: Classification of linseed genotypes according to reproductive organ position

NAME OF VARIETY	R-7	R-552	KIRAN	KARTIKA	IA-32	RLC-92
PHOTOGRAPH						
CLASS	ANTHERS SURROUNDS STIGMA CLOSELY	ANTHERS SURROUNDS STIGMA CLOSELY	ANTHERS SURROUNDS STIGMA CLOSELY	ANTHERS SURROUNDS STIGMA CLOSELY	ANTHERS SURROUNDS STIGMA CLOSELY	ANTHERS SURROUNDS STIGMA OPENLY

NAME OF VARIETY	RLC-133	RLC-138	RLC-143	RLC-148	RLC-153	RLC-161
PHOTOGRAPH						
CLASS	ANTHERS SURROUNDS STIGMA CLOSELY	ANTHERS SURROUNDS STIGMA OPENLY	ANTHERS SURROUNDS STIGMA CLOSELY	STIGMA BELOW ANTHER	STIGMA BELOW ANTHER	STIGMA BELOW ANTHER

NAME OF VARIETY	RLC-164	RLC-167	RLC-171	RLC-172	RLC-175	RLC-176
PHOTOGRAPH						
CLASS	ANTHERS SURROUNDS STIGMA CLOSELY	ANTHERS SURROUNDS STIGMA OPENLY	ANTHERS SURROUNDS STIGMA CLOSELY	ANTHERS SURROUNDS STIGMA CLOSELY	ANTHERS SURROUNDS STIGMA OPENLY	ANTHERS SURROUNDS STIGMA CLOSELY

NAME OF VARIETY	RLC-181	RLC-183	RLC-184	RLC-185	RLC-186	RLC-187
PHOTOGRAPH						
CLASS	ANTHERS SURROUNDS STIGMA OPENLY	ANTHERS SURROUNDS STIGMA OPENLY	STIGMA BELOW ANTHER	ANTHERS SURROUNDS STIGMA CLOSELY	ANTHERS SURROUNDS STIGMA CLOSELY	ANTHERS SURROUNDS STIGMA OPENLY

NAME OF VARIETY	RFC-19-1	RFC-19-2
PHOTOGRAPH		
CLASS	STIGMA ABOVE ANTHER	ANTHERS SURROUNDS STIGMA OPENLY

4.1.12 Stigma colour and style colour

Stigma and style colour were recorded after full opening of flower in morning and according to colour of stigma and style the whole genotypes were grouped into two categories such as white and blue. Out of twenty-six genotypes for stigma colour seventeen (62%) genotypes fall under the category of white and nine (38%) genotypes grouped as blue, for style colour eighteen (69%) genotypes grouped as white and eight (31%) genotypes grouped as blue.

Table 4.12: Classification of linseed genotypes according to stigma and style colour

NAME OF VARIETY	R-7	R-552	KIRAN	KARTIKA	IA-32	RLC-92
PHOTOGRAPH						
CLASS	BLUE STIGMA AND WHITE STYLE	WHITE STIGMA AND STYLE	WHITE STIGMA AND STYLE	WHITE STIGMA AND STYLE	BLUE STIGMA AND BLUE STYLE	WHITE STIGMA AND BLUE STYLE

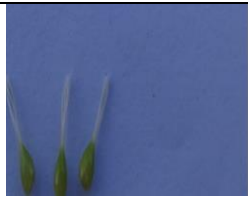
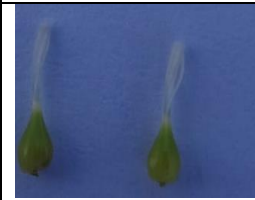
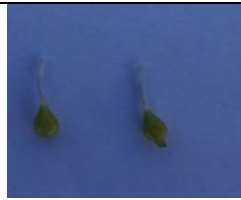
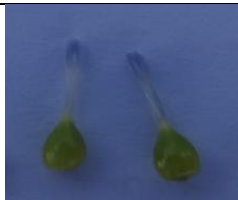
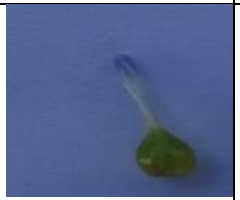
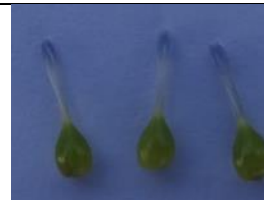
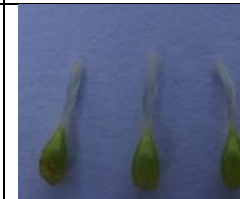
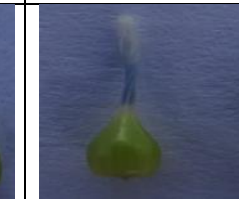
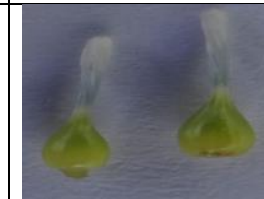
NAME OF VARIETY	RLC-133	RLC-138	RLC-143	RLC-148	RLC-153	RLC-161
PHOTOGRAPH						
CLASS	WHITE STIGMA AND STYLE	WHITE STIGMA AND STYLE	WHITE STIGMA AND STYLE	WHITE STIGMA AND STYLE	BLUE STIGMA AND STYLE	BLUE STIGMA AND STYLE

Table 4.12: Classification of linseed genotypes according to stigma and style colour contd...

NAME OF VARIETY	RLC-164	RLC-167	RLC-171	RLC-172	RLC-175	RLC-176
PHOTOGRAPH						
CLASS	BLUE STIGMA AND STYLE	BLUE STIGMA AND STYLE	WHITE STIGMA AND STYLE	BLUE STIGMA AND WHITE STYLE	WHITE STIGMA AND STYLE	WHITE STIGMA AND BLUE STYLE

NAME OF VARIETY	RLC-181	RLC-183	RLC-184	RLC-185	RLC-186	RLC-187
PHOTOGRAPH						
CLASS	WHITE STIGMA AND BLUE STYLE	WHITE STIGMA AND STYLE	WHITE STIGMA AND BLUE STYLE	WHITE STIGMA AND BLUE STYLE	WHITE STIGMA AND BLUE STYLE	BLUE STIGMA AND WHITE STYLE

NAME OF VARIETY	RFC-19-1	RFC-19-2
PHOTOGRAPH		
CLASS	BLUE STIGMA AND WHITE STYLE	WHITE STIGMA AND STYLE

4.1.13 Capsule shape

Shape of capsule were recorded in full maturity stage. According to shape of the capsule the whole genotypes were divided into globular, pressed and conical. Out of twenty-six genotype twelve (46%) genotypes belonged to globular, six (23%) genotypes belonged to pressed and eight (31%) genotypes belonged to conical category.

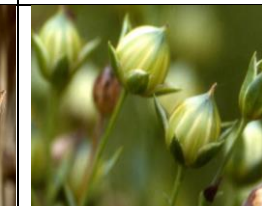
Table 4.13: Classification of linseed Genotypes according to capsule shape

NAME OF VARIETY	R-7	R-552	KIRAN	KARTIKA	IA-32	RLC-92
PHOTOGRAPH						
CLASS	PRESSED	GLOBULAR	GLOBULAR	GLOBULAR	CONICAL	GLOBULAR

NAME OF VARIETY	RLC-133	RLC-138	RLC-143	RLC-148	RLC-153	RLC-161
PHOTOGRAPH						
CLASS	CONICAL	PRESSED	GLOBULAR	PRESSED	PRESSED	GLOBULAR

Table 4.13: Classification of linseed Genotypes according to capsule shape contd...

NAME OF VARIETY	RLC-164	RLC-167	RLC-171	RLC-172	RLC-175	RLC-176
PHOTOGRAPH						
CLASS	CONICAL	PRESSED	GLOBULAR	CONICAL	CONICAL	PRESSED

NAME OF VARIETY	RLC-181	RLC-183	RLC-184	RLC-185	RLC-186	RLC-187
PHOTOGRAPH						
CLASS	GLOBULAR	GLOBULAR	GLOBULAR	GLOBULAR	CONICAL	CONICAL

NAME OF VARIETY	RFC-19-1	RFC-19-2
PHOTOGRAPH		
CLASS	GLOBULAR	CONICAL

4.1.14 Capsule shape of base

For recording the shape of base, the matured capsule were cut down longitudinally from the middle. According to shape of the base the genotypes are divided into two category such as circular and heart shaped. Out of twenty-six genotypes sixteen (62%) genotypes belonged to class circular base and ten (38%) genotypes belonged to class having heart shaped base.

Table 4.14: Classification of linseed genotypes according to capsule shape of base

NAME OF VARIETY	R-7	R-552	KIRAN	KARTIKA	IA-32	RLC-92
PHOTOGRAPH						
CLASS	CIRCULAR	HEART SHAPED	HEART SHAPED	HEART SHAPED	CIRCULAR	CIRCULAR

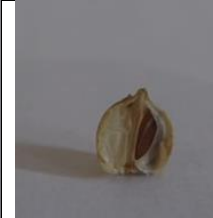
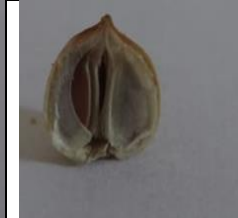
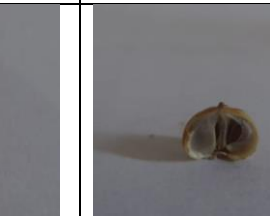
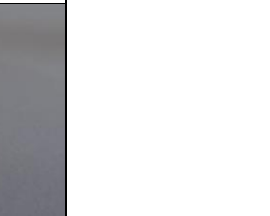
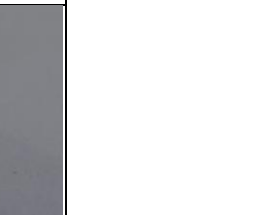
NAME OF VARIETY	RLC-133	RLC-138	RLC-143	RLC-148	RLC-153	RLC-161
PHOTOGRAPH						
CLASS	CIRCULAR	HEART SHAPED	CIRCULAR	CIRCULAR	CIRCULAR	CIRCULAR

Table 4.14: Classification of linseed genotypes according to capsule shape of base contd...

NAME OF VARIETY	RLC-164	RLC-167	RLC-171	RLC-172	RLC-175	RLC-176
PHOTOGRAPH						
CLASS	HEART SHAPED	HEART SHAPED	CIRCULAR	HEART SHAPED	HEART SHAPED	CIRCULAR

NAME OF VARIETY	RLC-181	RLC-183	RLC-184	RLC-185	RLC-186	RLC-187
PHOTOGRAPH						
CLASS	HEART SHAPED	CIRCULAR	CIRCULAR	CIRCULAR	HEART SHAPED	HEART SHAPED

NAME OF VARIETY	RFC-19-1	RFC-19-2
PHOTOGRAPH		
CLASS	CIRCULAR	CIRCULAR

From the above morphological characterization the overlapping genotypes can be differentiated from one another to a certain extent by the characters like petal margin shape, petal margin folding and reproductive organ positions represented below in tabular form.

Table 4.15: List of overlapping genotypes with differentiable traits

S .no	Genotypes	Differentiable traits
1	RLC-148	Crenate margin with inward folding
2	RLC-153	Even margin with plain folding
3	RLC-161	Crenate margin with plain folding
4	RLC-164	Crenate margin, inward folding with anthers surrounds stigma closely
5	RLC-167	Even margin, plain folding with anthers surrounds stigma openly

The result shows similarity with Kerkhi *et. al* (2002) who studied diverse linseed genotypes using nine to ten morphological characters for differentiating genotypes.

Similarly, Dhirhi *et.al* (2016) studied 150 linseed genotypes for DUS testing using morphological and yield contributing traits.

Table 4.16: Morphologically distinguishing character of linseed genotype during *rabi* 2020-21 at Raipur (C.G)

S. no	Character Genotype	→ ↓	Shape of cotyledon	Anthocyanin colour of hypocotyl	Leaf colour	Inflorescence shape	Petal colour	Petal aestivation	Petal margin shape	Petal margin folding
1	R-7		Oval	Present	Dark green	Branchy	Violet blue	Semi twisted	Coarsely crenate	Folded inward
2	R-552		Circular	Absent	Green	Compact	Violet blue	Semi twisted	Crenate	Plain
3	Kiran		Elliptical	Present	Light green	Moderately branchy	Violet	Twisted	Crenate	Folded inward
4	KARTIKA		Elliptical	Present	Green	Branchy	Blue	Twisted	Even	Plain
5	IA-32		Elliptical	Present	Green	Branchy	Blue	Semi twisted	Crenate	Plain
6	RLC-92		Oval	Absent	Dark green	Branchy	Light blue	Semi twisted	Crenate	Plain
7	RLC-133		Oval	Absent	Green	Branchy	White	Valvate	Coarsely crenate	Folded inward
8	RLC-138		Oval	Present	Green	Moderately branchy	Blue	Twisted	Crenate	Plain
9	RLC-143		Elliptical	Absent	Green	Compact	Light blue	Semi twisted	Crenate	Plain
10	RLC-148		Circular	Present	Light green	Branchy	Light blue	Twisted	Crenate	Folded inward
11	RLC-153		Elliptical	Plain	Green	Branchy	Light blue	Valvate	Even	Plain
12	RLC-161		Oval	Plain	Light green	Branchy	Light blue	Valvate	Crenate	Plain
13	RLC-164		Elliptical	Absent	Green	Moderately branchy	Light blue	Valvate	Crenate	Folded outward
14	RLC-167		Oval	Absent	Green	Branchy	Light blue	Valvate	Even	Plain
15	RLC-171		Circular	Plain	Dark green	Compact	Blue	Semi twisted	Crenate	Plain
16	RLC-172		Oval	Present	Light green	Branchy	Light blue	Twisted	Even	Folded outward
17	RLC-175		Elliptical	Present	Green	Branchy	Violet blue	Twisted	Coarsely crenate	Folded outward
18	RLC-176		Elliptical	Present	Dark green	Branchy	Blue	Valvate	Crenate	Plain
19	RLC-181		Oval	Present	Dark green	Moderately branchy	Blue	Twisted	Even	Folded outward
20	RLC-183		Circular	Present	Light green	Compact	Violet blue	Twisted	Crenate	Plain
21	RLC-184		Circular	Present	Dark green	Branchy	Blue	Valvate	Even	Plain
22	RLC-185		Oval	Absent	Dark green	Moderately branchy	Blue	Valvate	Even	Plain
23	RLC-186		Elliptical	Present	Green	Compact	Blue	Twisted	Even	Plain
24	RLC-187		Elliptical	Absent	Light green	Compact	Blue	Semi twisted	Crenate	Plain
25	RFC-19-1		Circular	Present	Green	Compact	Light blue	Twisted	Crenate	Folded outward
26	RFC-19-2		Circular	Present	Green	Moderately branchy	Blue	Semi twisted	Even	plain

Table 4. 16: Morphologically distinguishing character of linseed genotype during *rabi* 2020-21 at Raipur (C.G) contd...

S.no	Characters Genotypes	 Petal venation colour	Sepal termination	Sepal anthocyanin colour	Reproductive organ position	Stigma colour	Style colour	Capsule shape	Capsule shape of base
1	R-7	Violet	Longitudinally acute	Absent	Anther surrounds stigma closely	Blue	White	Pressed	Circular
2	R-552	Violet	Longitudinally acute	Absent	Anther surrounds stigma closely	White	White	Globular	Heart shaped
3	Kiran	Violet	Longitudinally acute	Absent	Anther surrounds stigma closely	White	White	Globular	Heart shaped
4	KARTIKA	Blue	Longitudinally acute	Absent	Anther surrounds stigma closely	white	White	Globular	Heart shaped
5	IA-32	Blue	Acute	Absent	Anther surrounds stigma closely	Blue	Blue	Conical	Circular
6	RLC-92	Blue	Longitudinally acute	Absent	Anther surrounds stigma openly	White	Blue	Globular	Circular
7	RLC-133	White	Longitudinally acute	Absent	Anther surrounds stigma closely	White	White	Conical	Circular
8	RLC-138	Blue	Acute	Absent	Anther surrounds stigma closely	White	White	Pressed	Heart shaped
9	RLC-143	Blue	Acute	Absent	Anther surrounds stigma closely	White	White	Globular	Circular
10	RLC-148	Blue	Longitudinally acute	Absent	Stigma below anther	White	White	Pressed	Circular
11	RLC-153	Blue	Longitudinally acute	Absent	Stigma below anther	Blue	White	Pressed	Circular
12	RLC-161	Blue	Longitudinally acute	Absent	Stigma below anther	Blue	White	Globular	Circular
13	RLC-164	Blue	Acute	Absent	Anther surrounds stigma closely	Blue	White	Conical	Heart shaped
14	RLC-167	Blue	Longitudinally acute	Absent	Anther surrounds stigma openly	Blue	White	Pressed	Circular
15	RLC-171	Blue	Acute	Absent	Anther surrounds stigma closely	White	Blue	Globular	Circular
16	RLC-172	Blue	Longitudinally acute	Absent	Anther surrounds stigma closely	Blue	White	Conical	Heart shaped
17	RLC-175	Violet	Acute	Absent	Anther surrounds stigma openly	White	White	Conical	Heart shaped
18	RLC-176	Blue	Longitudinally acute	Absent	Anther surrounds stigma closely	White	Blue	Pressed	Circular
19	RLC-181	Blue	Acute	Absent	Anther surrounds stigma openly	White	Blue	Globular	Heart shaped
20	RLC-183	Violet	Acute	Absent	Anther surrounds stigma openly	White	White	Globular	Circular
21	RLC-184	Blue	Acute	Absent	Stigma below anther	White	Blue	Globular	Circular
22	RLC-185	Blue	Longitudinally acute	Absent	Anther surrounds stigma closely	White	Blue	Globular	Circular
23	RLC-186	Blue	Acute	Absent	Anther surrounds stigma closely	White	Blue	Conical	Heart shaped
24	RLC-187	Blue	Acute	Absent	Anther surrounds stigma openly	Blue	White	Conical	Heart shaped
25	RFC-19-1	Blue	Longitudinally acute	Absent	Stigma above anther	Blue	White	Globular	Circular
26	RFC-19-2	Blue	Longitudinally acute	Absent	Anthers surrounds stigma openly	White	White	Conical	Circular

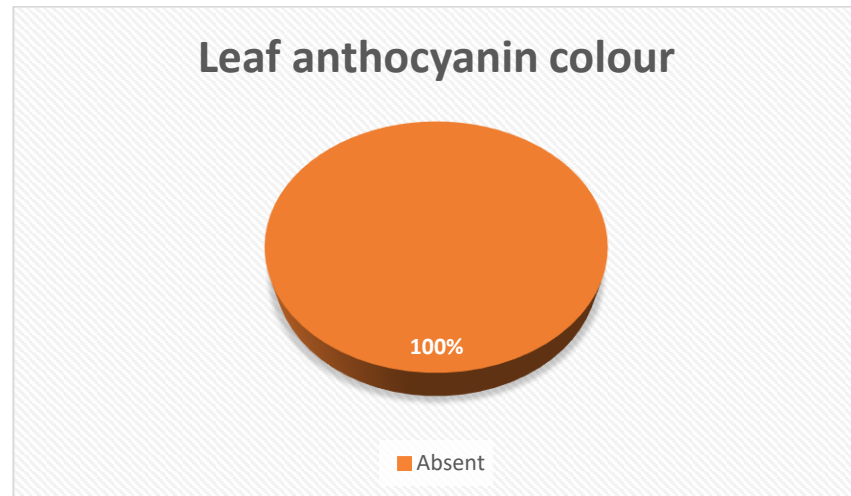
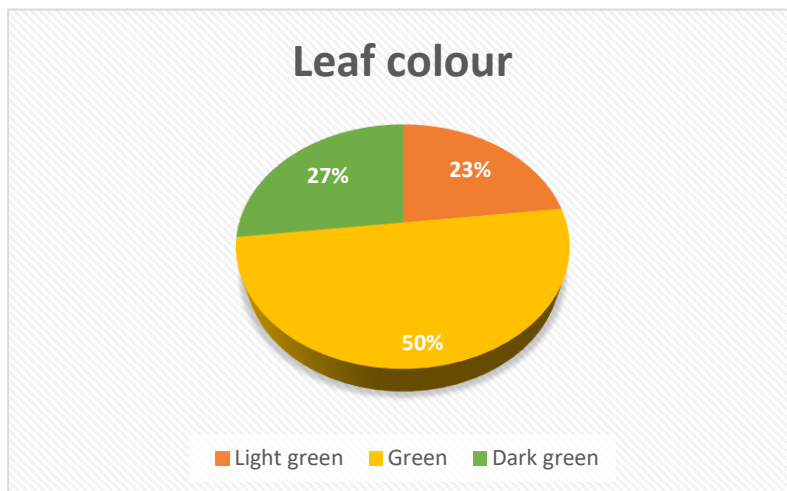
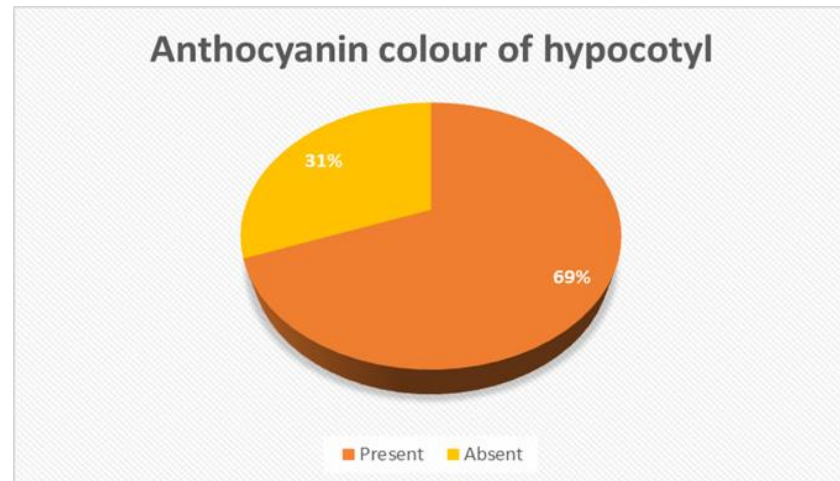
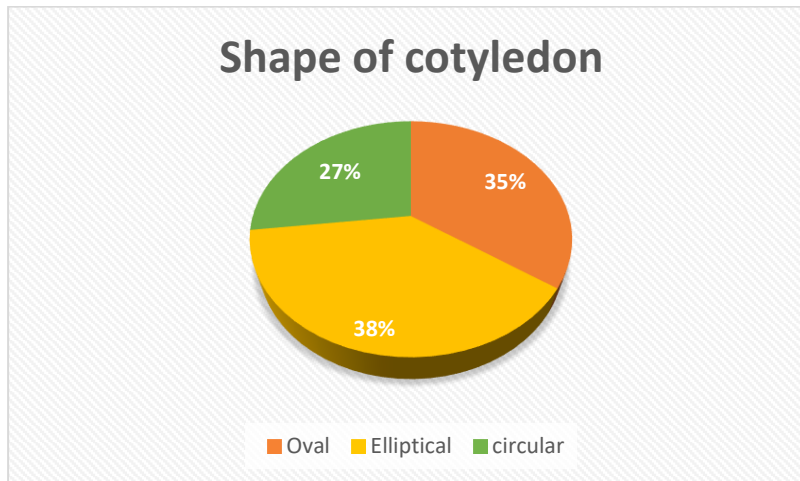


Fig. 4.1: Graphical representation of morphological characters in linseed genotypes through pie charts.

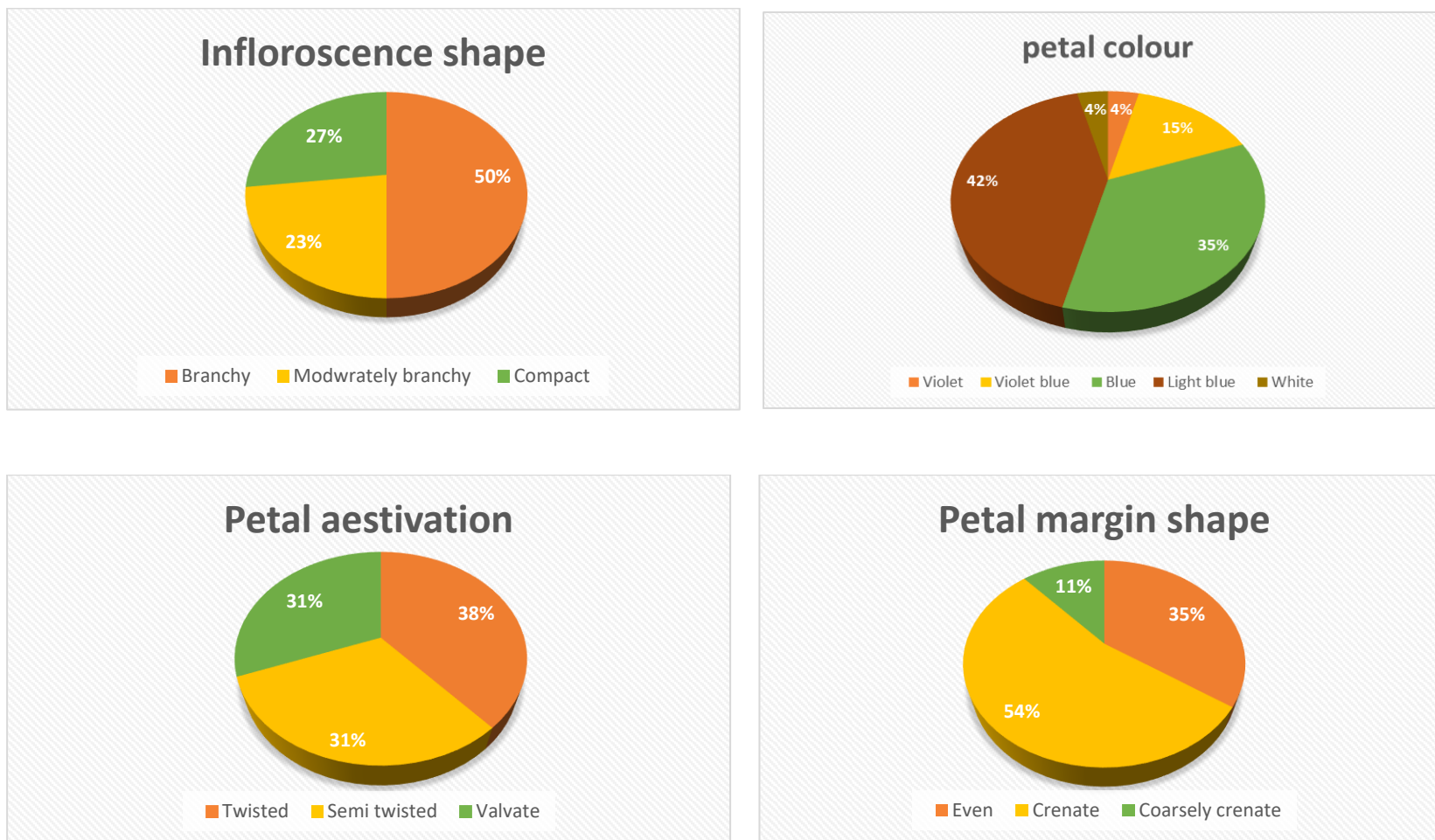


Fig. 4.1: Graphical representation of morphological characters in linseed genotypes through pie charts (contd...)

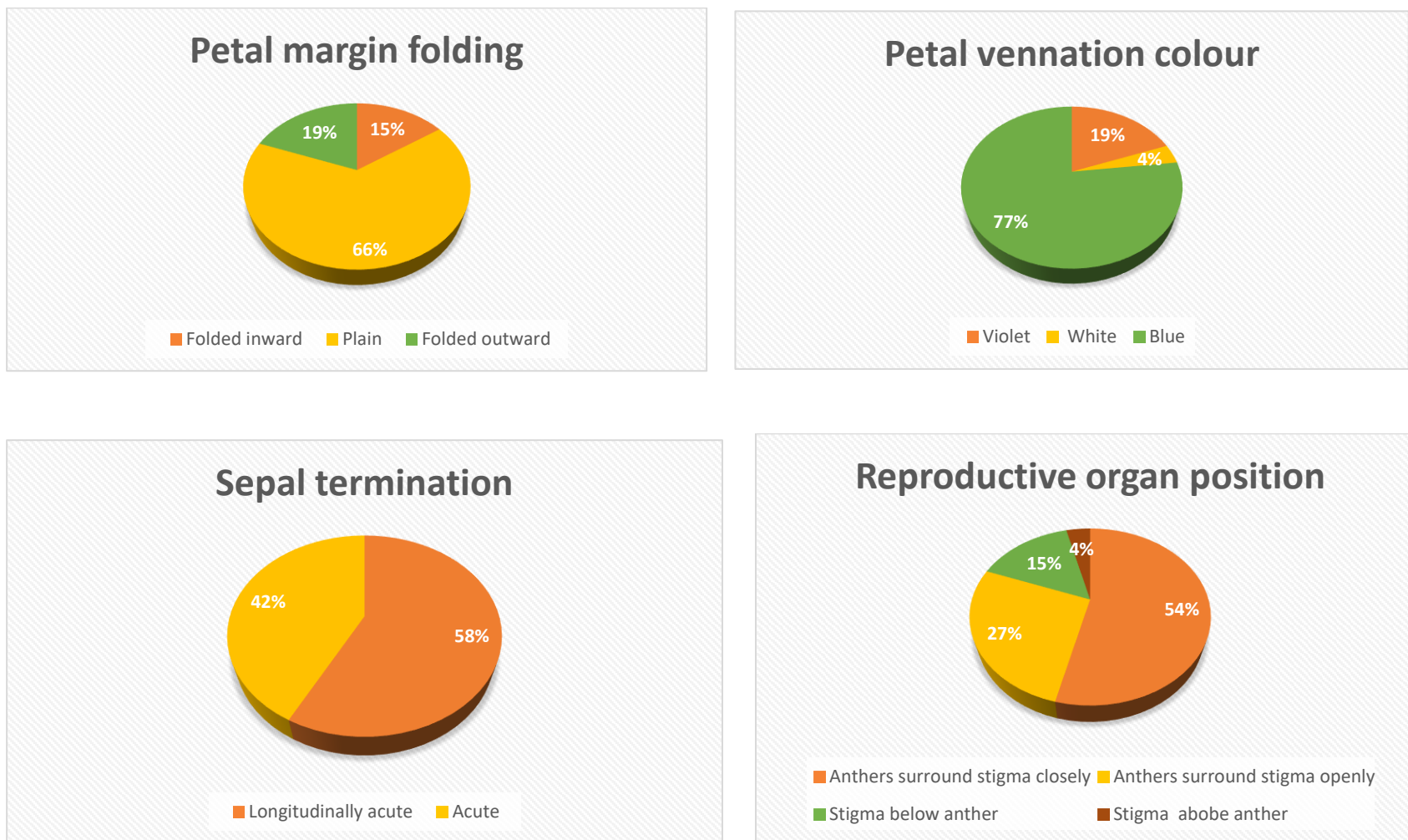


Fig. 4.1: Graphical representation of morphological characters in linseed genotypes through pie charts (contd...)

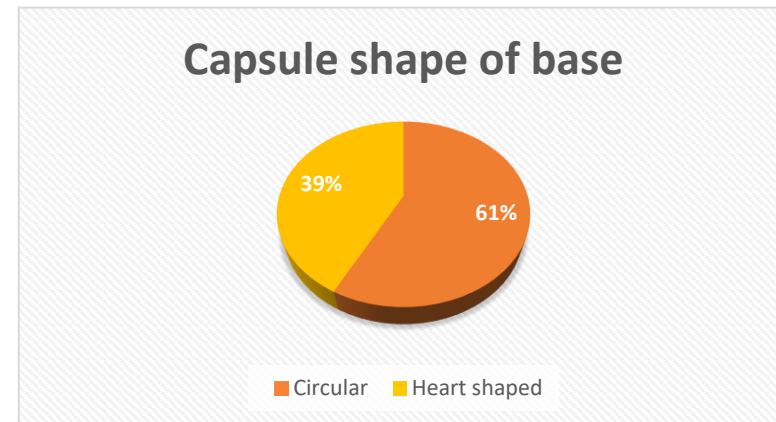
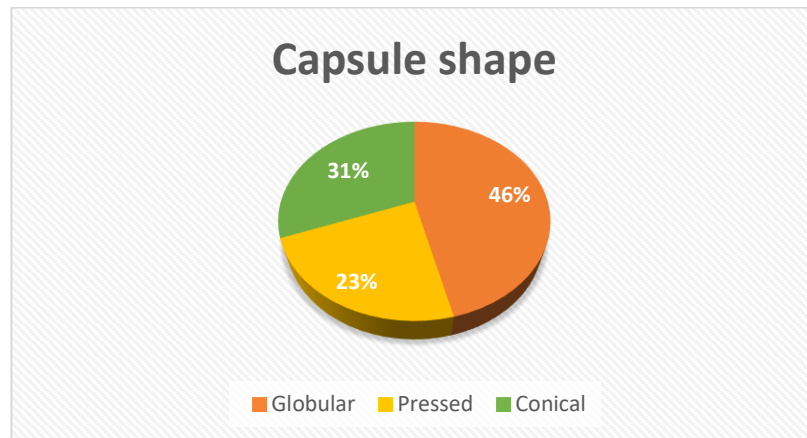
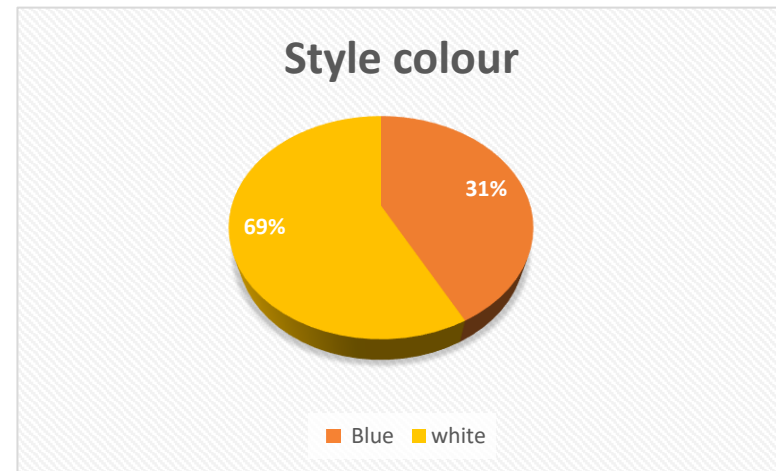
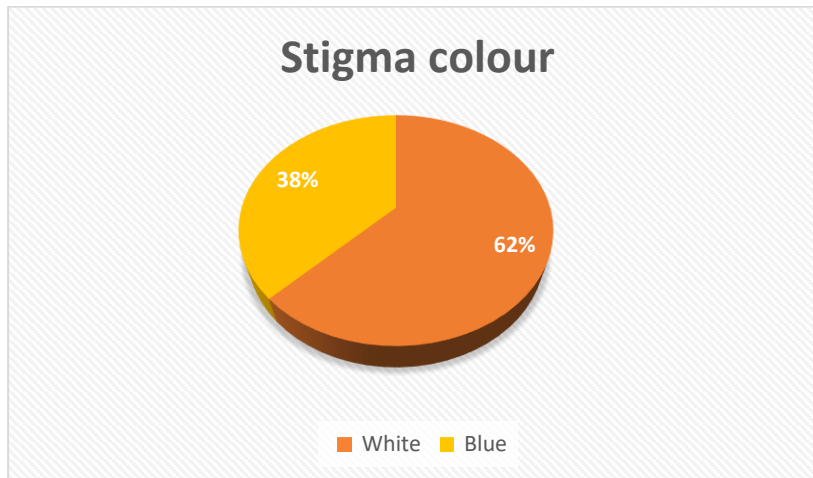


Fig. 4.1: Graphical representation of morphological characters in linseed genotypes through pie charts (contd...)

4.2 Analysis of variance –

Analysis of variance (ANOVA) is a collection of statistical models and associated estimate processes (such as "variation" among and between groups) that are used to examine variations in means. Ronald Fisher, a statistician, invented ANOVA. ANOVA is based on the law of total variance, which divides observed variance in a variable into components attributed to various causes of variation.

“Genetic enhancement of the linseed crop can be successfully performed using substantial genetic information on the linseed crop, either through direct enhancement of qualities in which plant breeders are interested or indirect enhancement through component traits”. The presence of genetic variability for seed yield and its enhancement, as well as the type of association among themselves, is a vital prerequisite for reaching the ultimate aim of attaining high quality seed yield. The genotypes of linseed were highly significant for all of the traits studied, according to analysis of variance. Analysis was carried out for fifteen characters such as “ total plant height(mm), stem thickness(mm),epicotyl branching,leaf length(mm), diameter of open flower(mm),capsule width(mm), capsule per plant,seed length(mm), seed width,1000 seed weight, seed weight per plant, length of flowering or flowering period, days from seedling to early yellow maturity , days from seedling to full maturity and seed yield per hectare . This reveals that there is sufficient variation between linseed genotypes for seed yield, and its attributing traits are listed in Table 4.16.

Analysis of variance clearly indicated that there was highly significant variation amongst the genotypes for all the traits studied, as according to Tadesse *et al.* (2010), Reddy *et al.* (2013), Tyagi *et al.* (2014), Kanwar *et al.* (2014), Singh *et al.* (2015), Patial *et al.* (2018), and Dhirhi and Mehta (2019).

Table 4.17: Analysis of variance of linseed genotypes 2020-21 at Raipur (C.G)

Mean sum of square										
S .no.	Source of variance	Degree of freedom	Total plant height (mm)	Stem thickness(mm)	Epicotyl branching	Leaf length(mm)	Dia. Of open flower (mm)	Capsule width (mm)	Capsule/plant	Seed length(mm)
1	Replication	2	10128.8	0.06	0.09	11.05	4.31	0.61	4.15	0.03
2	Genotype	25	44444.72**	2.8**	2.6**	13.04**	15.47**	2.22**	831.40**	0.67**
3	Error	50	3486.32	0.07	0.16	4.84	1.74	0.29	9.29	0.01

Mean sum of square									
S .no.	Source of variance	Degree of freedom	Seed width(mm)	1000 seed weight (g)	Length of flowering	Seedling to yellow maturity	Days to maturity	Seed weight/plant (g)	
1	Replication	2	0.01	0.03	1.49	17.17	287.16	0.03	
2	Genotype	25	0.21**	2.29**	153.62**	156.69**	281.81**	1.39**	
3	Error	50	0.01	0.16	7.04	40.14	99.41	0.04	

* Significant at 5% level, ** Significant at 1% level

4.3 Range and mean performances of different parameter

For seed yield and its component traits ,the Mean performances for linseed genotypes were compared with checks (RLC-92, RLC-143, RLC-148, RLC-153) which is given in the table 4.17 are discussed below .

Total plant height (mm)

Range of total plant height varied in between 462 mm in RLC-172 to 921 mm in RLC-187 which showing higher in performance than all the checks RLC-92 (772 mm), RLC-143(543 mm), RLC-148 (747 mm), RLC-153 (705 mm). The mean value for plant height was 678 mm . highest value was observed in RLC-187 which was followed by RFC-19-2 and RFC-19-1 having 912 mm and 906mm respectively. The trait contributed 8.71% CV.

Stem thickness (mm)

Range of stem thickness varied in between 2.62 in RFC-19-2 mm to 6.61 in RLC-167 which showing higher in performance than all the checks RLC-92 (6.5mm), RLC-143(3.90mm) , RLC-148(6.15mm), RLC-153(5.67mm).The mean value for stem thickness was 4.95mm. the trait contributed 5.56% CV.

Epicotyl branching

The range for epicotyl branching varied in between 3.30mm in RFC-19-2 to 7.40mm in RLC-172 . RFC-19-2 showed the least value which was lesser than all the check having epicotyl branching 6.62, 3.90, 5.50, 5.90 for genotype RLC-92,RLC-143,RLC-148 andRLC-153 respectively. The mean value was 4.9 and the traits contributed 8.15% to CV.

Leaf length (mm)

Range of leaf length varied between 28 mm and 37 mm. the lower value showed by RLC-172 and higher value shown by RLC-171. The mean value for the character is 31.97mm and the traits contributed 6.88% to CV. RLC-171 shown higher performances than all the checks RLC-92 (35 mm), RLC-143 (29 mm), RLC-148 (31 mm), RLC-153 (32 mm).

Diameter of open flower

The range for diameter of open flower varied in between 15 mm in RLC-138 to 24 mm in RLC-164. The mean value of the trait was 20 mm and the trait contributed 6.51% to CV. Least value shown by RLC-138 which was lesser than all the four check having diameter as RLC-92 (21 mm), RLC-143 (22 mm), RLC-148(21 mm) and RLC-153(21 mm) respectively.

Capsule width(mm)

The range for capsule width varied in between 5.16 mm in RFC-19-1 to 8.59 mm in RLC-175. The mean value of the trait was 7.12mm and the trait contributed 7.60% to CV. Least value shown by RFC-19-1 which was lesser than all the four check having diameter as RLC-92 (7.7mm), RLC-143 (5.84mm), RLC-148(6.52mm), RLC-153(8.05mm) respectively.

Number of capsule per plant

The range for number of capsule per plant varied between 21.50 to 90.30 with a mean value of 49 capsule per plant. The trait contributed 6.24 % to CV. The lowest value shown by RLC-184 and the highest value shown by RLC-172 showing higher in performances than the checks having RLC-92 (40), RLC-143 (55) , RLC-148(69), RLC-153(55) capsules per plant respectively.

Seed length (mm)

The range for seed length varied in between 4.03mm to 5.43mm with a mean value of 4.66mm . the lowest value shown by RFC-19-1 and highest value shown by RLC-183 showing higher performances than the check RLC-92 (5.27mm), RLC-143 (5.03mm), RLC-148(4.47mm), RLC-153(4.27mm) respectively. The trait contributed 7.10% to CV.

Seed width (mm)

The range for seed width varied in between 1.47mm to mm with a mean value of 2.43mm , with a mean value of 1.95mm. The lowest value shown by RFC-19-2 and highest value shown by RLC-183 showing higher performances than the check

RLC-92 (2.27mm), RLC-143 (2.13mm) , RLC-148(2.07mm), RLC-153(1.73 mm) respectively. The trait contributed 7.10% to CV.

1000 seed weight

The range of 1000 seed weight varied between 4.63g to 7.70g with a mean value of 5.88g. The lowest value shown by RLC-184 and highest value shown by RLC-92 showing higher performances than all the genotypes. The trait contributed 6.98% to CV.

Length of flowering-

The range for length of flowering varied in between 32 days to 62 days with the mean value of 47 days. The lowest length shown by RLC-161 and highest length shown by RLC-176 showing higher performances than the check RLC-92(40 days), RLC-143 (37 days) , RLC-148(48 days) , RLC-153(40.10 days) respectively. The trait contributed 5.68% to CV.

Days from seedlings to early yellow maturity-

The range for days to yellow maturity varied in between 67 days to 97 days with a mean value of 85 days. The lowest length shown by R-7 and highest length shown by RFC-19-1 showing higher performances than the check RLC-92(79.43 days), RLC-143 (79 days) , RLC-148(86 days) , RLC-153(76 days) respectively. The trait contributed 7.49% to CV.

Days from seedlings to full maturity-

The range for days to full maturity varied in between 99 days to 138 days with a mean value of 120 days. The lowest length shown by kiran and highest length shown by RFC-19-2 showing higher performances than the check RLC-92(118 days), RLC-143 (116 days) , RLC-148(117 days) , RLC-153(111days) respectively. The trait contributed 8.28% to CV

Seed weight per plant-

The range for seed weight per plant varied in between 1.45g to 4.23g with the mean value of 2.58g per plant. The lowest value shown by RLC-184 and highest

value shown by RLC-172 showing higher performances than the check RLC-92(3.29g) RLC-143 (2.55g) , RLC-148 (2.60g), RLC-153(2.15g) respectively. The trait contributed 8.36% to CV.

Seed yield per hectare

The range of seed yield per hectare varied in between 4.83 Qt/ha to 14.10 Qt/ha having a mean value of 8.59Qt/ha . The lowest value shown by RLC-184 and highest value shown by RLC-172 showing higher performances than the check RLC-92(10.95 Qt/ha) RLC-143 (8.51 Qt/ha), RLC-148(8.66 Qt/ha), RLC-153(7.16Qt/ha) respectively. The trait contributed 6.32% to CV.

Table 4.18: Mean performance for seed yield and its component traits during 2020-21 at Raipur (C.G)

S.no	Genotypes	Total plant height (mm)	Stem thickness(mm)	Epicotyl branching	Leaf length(mm)	Dia. Of open flower (mm)	Capsule width (mm)	Capsule/plant	Seed length(mm)
1	R-7	518	5.53	4.8	32.5	21	7.81	45.06	5.13
2	R-552	577	5.44	4.6	32	18	8.21	47.03	5.26
3	KIRAN	630	4.97	4.4	33	18	6.43	65.8	4.3
4	KARTIKA	524	4.98	4.9	29	21	6.32	77.63	4.13
5	IA-32	643	6.06	5.3	35.5	21	8.00	53.6	5.23
6	RLC-92	772	6.50	6.6	34.5	21	7.70	40.1	5.26
7	RLC-133	757	4.72	4.9	32	16	7.19	63.33	4.86
8	RLC-138	569	4.17	4.7	32	15	7.90	39.9	4.06
9	RLC-143	543	3.89	4.3	29	22	5.84	54.5	5.03
10	RLC-148	747	6.14	5.5	31	21	6.52	69.3	4.46
11	RLC-153	705	5.67	5.9	32	21	8.05	54.6	4.26
12	RLC-161	795	5.5	5	30	18	7.23	23.3	4.86
13	RLC-164	635	4.94	6.4	32	24	6.97	43.3	4.5
14	RLC-167	694	6.6	5.3	35	20	7.58	50.9	4.66
15	RLC-171	778	6.09	3.7	37	23	8.08	29.46	4.63
16	RLC-172	462	4.90	7.4	28	19	7.0	90.3	4.26
17	RLC-175	713	5.58	4.63	33	21	8.59	76.03	5.16
18	RLC-176	573	4.67	4.7	31	22	7.0	41.13	5.36
19	RLC-181	696	4.50	5.5	31	19	7.47	45.63	4.16
20	RLC-183	626	4.72	5.5	30	18	6.76	45.6	5.43
21	RLC-184	633	5.05	4.9	33	21	7.66	21.5	4.26
22	RLC-185	659	3.76	4.2	30	23	6.34	34.13	5.06
23	RLC-186	649	4.19	4.2	31	23	6.84	40	4.43
24	RLC-187	921	3.55	4.2	33	19	5.48	38.46	4.13
25	RFC-19-1	906	3.69	3.5	32	21	5.16	39.66	4.03
26	RFC-19-2	912	2.62	3.3	31	21	6.82	39.4	4.04
Mean		678	4.95	4.95	32	20	7.12	48.87	4.66
C.V.		8.71	5.56	8.15	6.88	6.51	7.6	6.24	7.1
S.E.m+_		34.09	0.16	0.23	1.27	0.76	0.31	1.76	0.19

Table 4.18: Mean performance for seed yield and its component traits during 2020-21 at Raipur (C.G) contd...

S.no	Genotypes	Seed width(mm)	1000 seed weight (g)	Length of flowering	Days from Seedling to early yellow maturity	Days from seedling to maturity	Seed weight/plant (g)	Yield/ha (Qt.)
1	R-7	2.2	7.06	45	67	99	2.76	9.21
2	R-552	2.23	6.73	38	85	119	3.37	11.24
3	KIRAN	2.05	5.36	41	71	99	2.46	8.2
4	KARTHIKA	1.96	4.93	44	84	119	3.08	10.26
5	IA-32	2.33	4.9	47	84	116	2.33	7.78
6	RLC-92	2.26	7.7	40	79	118	3.28	10.95
7	RLC-133	2.03	6.33	37	84	113	3.57	11.89
8	RLC-138	1.73	5.13	50.	86	116	2.36	7.88
9	RLC-143	2.13	5.13	37	79	115	2.55	8.50
10	RLC-148	2.06	5.73	47	86	117	2.6	8.66
11	RLC-153	1.73	5.06	40	75	111	2.15	7.16
12	RLC-161	2.03	6.11	31	74	112	2.33	7.78
13	RLC-164	1.86	6.18	43	78	114	2.34	7.79
14	RLC-167	1.76	6.05	51	86	125	2.66	8.88
15	RLC-171	1.86	6.33	46	88	124	2.97	9.91
16	RLC-172	1.53	6.66	49	89	128	4.23	14.10
17	RLC-175	2.23	5.66	51	87	129	3.38	11.28
18	RLC-176	2.26	7.2	62	92	133	2.95	9.82
19	RLC-181	1.73	7.18	57	90	127	3.11	10.37
20	RLC-183	2.43	5.26	53	93	128	2.17	7.24
21	RLC-184	1.73	4.63	46	87	123	1.45	4.82
22	RLC-185	2.03	6.8	46	92	129	2.14	7.14
23	RLC-186	1.83	5.38	54	87	125	1.77	5.90
24	RLC-187	1.6	4.96	54	81	120	1.65	5.49
25	RFC-19-1	1.56	5.05	50	97	136	1.6	5.33
26	RFC-19-2	1.46	5.13	55	95	138	1.74	5.79
	Mean	1.95	5.88	47	85	120	2.58	8.59
	C.V.	6.06	6.98	5.68	7.49	8.28	8.36	6.32
	S.E.m+₁	0.07	0.24	1.53	3.66	5.76	0.12	0.31

4.4 Genetic variability-

According to the result of this research, “phenotypic coefficients of variation for all the traits under consideration were found to be higher than their corresponding genotypic coefficients of variation, showing masking effect of environment in the expression of traits,” as shown in Table 4.18

The highest genotypic coefficient of variation was observed for the character number of capsules per plant 33.87% followed by seed weight per plant 25.95%, stem thickness 19.58%, epicotyl branching 18.38% other traits shows moderate amount of genetic coefficient of variation. Whereas highest phenotypic coefficient of variation was shown by number of capsules per plant 34.44%, followed by stem thickness 20.36%, epicotyl branching 20.10%. This clearly indicate that there is a little difference between GCV and PCV for the character which signify that there is influence of genetic cause for expression of these traits.

The traits such as number of capsule per plant, seed yield per hectare, seed weight per plant, stem thickness, epicotyl branching showing high genetic coefficient of variation and phenotypic coefficient of variation indicates the presence of sufficient quantity of variations. By selecting these traits there is ample amount of scope to improve the genotypes.

The lowest amount of GCV was found in leaf length 5.17%, days to full maturity 6.47% and days from seedlings to yellow maturity 7.3%. Similarly lowest PCV was found in leaf length 8.61%, days to full maturity 10.5% and days from seedlings to yellow maturity 10.51%.

The result of present study is in agreement with the finding of Payasi *et al.* (2000) which state that “PCV values were higher than the GCV value for the character like number of capsule per plant indicating the apparent variation is not only because of genotypes but, also there is influence of environment variation. As a result, phenotypes must be prioritized for successful selection of these features, as the environment exhibits unpredictable variations in nature.

Table no. 4.19: Genetic Parameter of variation for seed weight per plant and its component traits in linseed genotypes 2020-21 at Raipur (C.G.)

S.no	Parameter	Mean	Range		Critical differences at 5%	Coefficient of variations%		h ² (Broad Sense)	GA	GA% of mean
	characters		Max.	Min.		GCV	PCV			
1	Total plant height (mm)	678.27	920.67	462.33	96.83	17.22	19.30	79.65	214.83	31.67
2	Stem thickness(mm)	4.95	6.61	2.62	0.45	19.58	20.36	92.53	1.92	38.81
3	Epicotyl branching	4.9	7.40	3.3	0.66	18.38	20.10	83.57	1.71	34.61
4	Leaf length(mm)	31.97	36.63	27.97	3.61	5.17	8.61	36.08	2.04	6.4
5	Dia. Of open flower(mm)	20.31	23.53	14.57	2.17	10.53	12.37	72.38	3.74	18.45
6	Capsule width(mm)	7.12	8.59	5.16	0.89	11.26	13.59	68.73	1.37	19.24
7	No of capsule/plant	48.87	90.3	21.50	5.00	33.87	34.44	96.71	33.53	68.62
8	Seed length(mm)	4.66	5.43	4.03	0.54	9.35	11.75	63.44	0.71	15.35
9	Seed width(mm)	1.95	2.43	1.47	0.19	13.39	14.70	83.02	0.49	25.14
10	1000 seed weight(g)	5.88	7.70	4.63	0.67	14.31	15.92	80.80	1.55	26.51
11	Length of flowering	46.74	61.73	31.07	4.35	14.95	15.99	87.40	13.46	28.79
12	Days from seed lings to early yellow maturity	84.54	96.9	67.47	10.39	7.37	10.51	49.18	9	10.65
13	Days to full maturity	120.46	138.47	98.74	16.35	6.47	10.50	37.94	9.89	8.21
14	Seed weight per plant	2.58	4.23	1.45	0.35	25.95	27.27	90.61	1.31	50.90

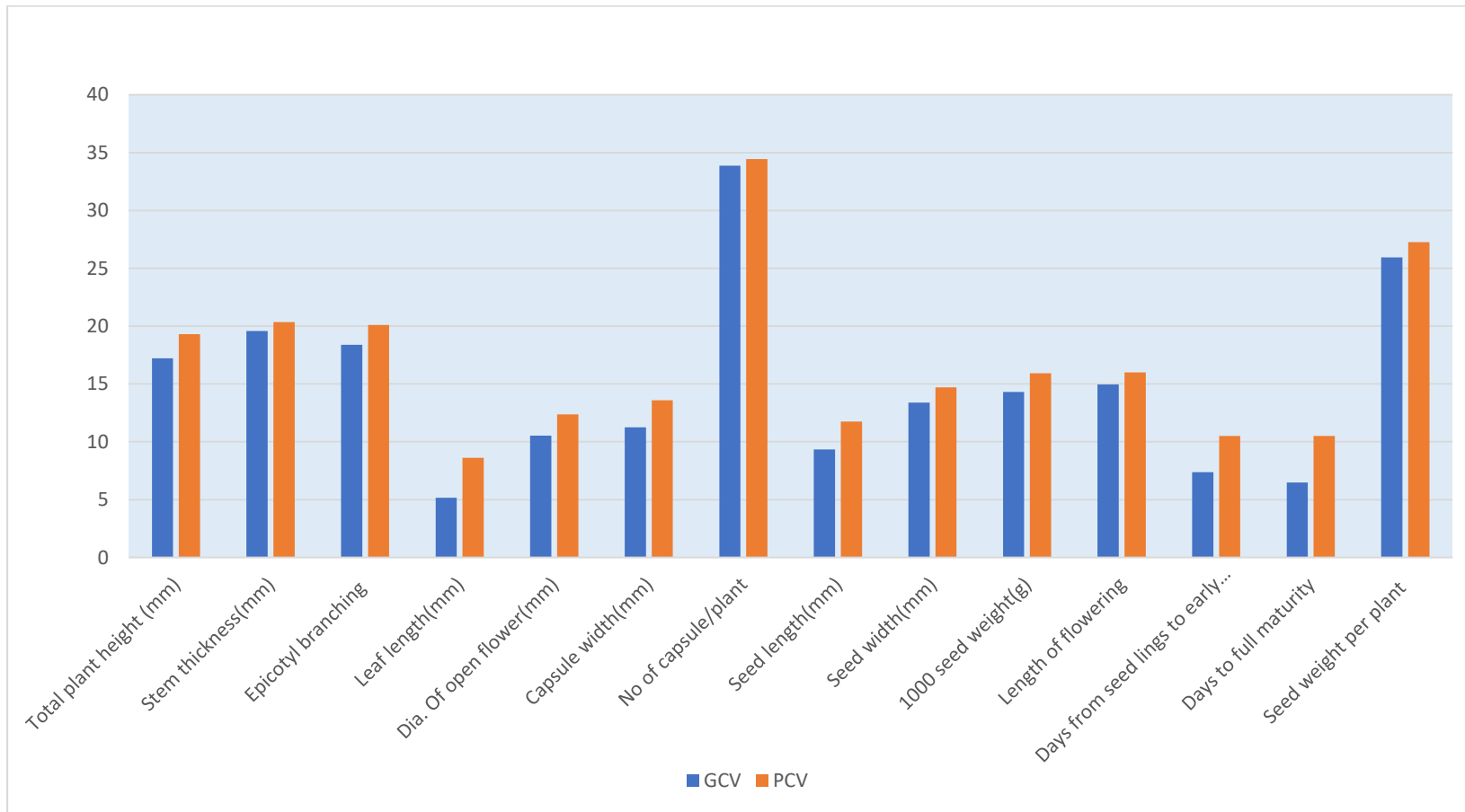


Fig. 4.2 Graphical representation of compairision between GCV and PCV

4.5 Heritability and genetic advance

The degree of similarity between phenotypic and breeding value is measured by heritability. It refers to the heritable component of phenotypic variation. In the selection of superior genotypes from genetically diverse populations, heritability plays a significant role. Heritability strictly valid to the population from which they are formed. In order to understand the relative influence of genetics and environment on phenotypic variation, broad sense heritability is useful. According to Robinson, the estimation of heritability can be divided into three categories: low (0–50 %), medium (50–70 %), and high (>70 %) (1966). For each yield attributing trait under investigation, broad sense heritability was assessed. (Figure 4.3)

Genetic advance, which is a key element in plant breeding, provides an estimate of reliable gain at a given degree of selection based on scientific evidence. As a result, heritability combined with genetic advance is useful in emphasizing seed yield and its components in selection. The proportion of trait improvement, on the other hand, would be more dependent on the degree of diversity in the population where selection is required. According to Johnson et al. (1996), the average genetic advance was divided into three categories: low (less than 10%), medium (10-20%), and high (more than 20%).

The highest heritability was observed for the trait number of capsule per plant 96.71% followed by stem thickness 92.53%. The lowest heritability was observed in leaf length 36.08%.

The genetic advance as % of mean was found to be highest in number of capsule per plant followed by seed weight per plant. The lowest value was observed in leaf length 6.4%.

Similar result also reported by Satpathi *et al.* (1987,1989), Mirza *et al.* (1996), Payasi *et al.* (2000), Akbar *et al.* (2003), Kant *et al.* (2005), Kumara and Rao (2007), Gauraha *et al.* (2011), Pali and Mehta (2013), Singh *et al.* (2015) and Dash *et al.* (2016) that “high heritability for number of capsule per plant”.

Similar finding also reported by Gauraha *et al.*, (2011), Rajanna *et al.* (2014) and Dash *et al.* (2016) reported that “high heritability coupled with high genetic advance as percent of mean was obtained for, number of capsules per plant which indicate that most likely the heritability might be due to additive gene action and selection may be effective in segregating generations.

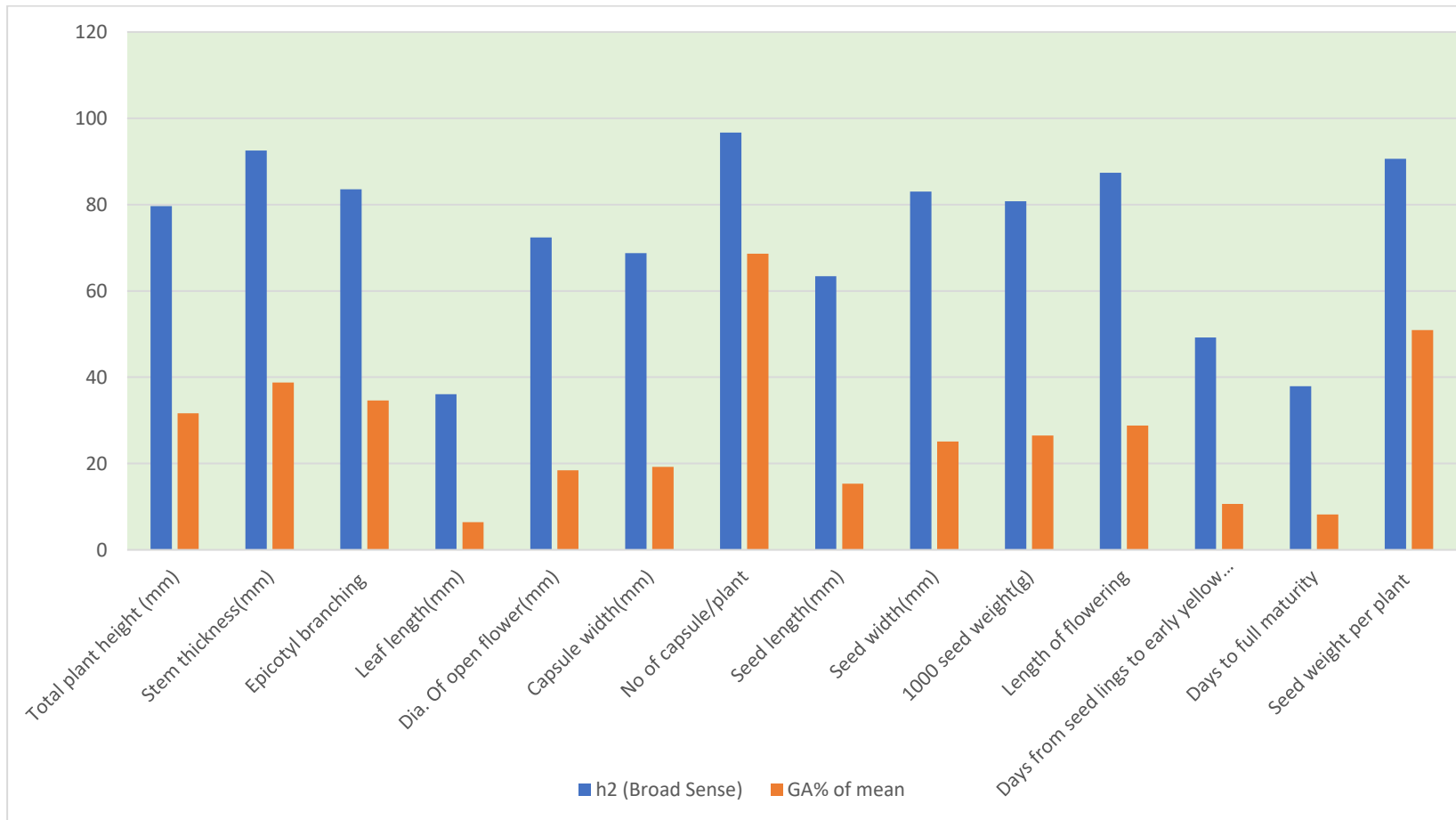


Fig.4.3: Graphical representation of comparison between heritability and genetic advance as percent of mean

4.6 Association analysis for seed yield and its attributing traits in linseed genotypes

Yield is a very complex and variable character which is result of additive effect of various character. The main trait of interest in most of the crop is seed yield, which is the result of the interaction of various component characters known as "yield components." As a result, identifying significant yield components and learning about their relationship with seed yield per hectare (qt/ha) is essential to understanding an effective breeding strategy for developing high-yielding varieties.

The correlation coefficient, which indicates the degree of association between two variables or features, aids in understanding the nature and amount of association between seed yield and yield components, which can be used to guide selection for crop yield for genetic improvement. The coupling phase of linkage is the cause of positive correlation at the genetic level. Negative correlation occurs when genes governing two distinct traits are linked in a repulsion phase. Pleiotropy, or developmental correlation, can cause both types of correlation. As there is no correlation, the genes in question are either far apart on the same chromosome or on separate chromosomes. Selection and hybridization can frequently alter the nature of correlation.

From the current experiment genotypic correlation coefficient and phenotypic correlation coefficient are shown in table no.4.19 &4.20.

The strong significant and positive correlation between seed yield per plant (g) and capsule per plant suggested that a high number of capsule per plant might indicate a higher seed yield. As a result, selection based on number of capsule per plant may be reliant on high seed yield for variety development.

According to correlation analysis, seed yield per plant was positively and strongly correlated with " capsule per plant ($r_g=0.95$, $r_p=0.60$), capsule width ($r_g=0.82$, $r_p=0.39$), 1000 seed weight ($r_g=0.78$, $r_p=0.58$) linseed genotypes, whereas positively and moderately related with other character such as stem thickness, seed length, seed width & epicotyl branching.

Similarly, analysis of correlation showed negative correlation with total plant height, diameter of open flower, length of flowering, days to seedlings to full maturity.

The result obtained by this research shows similarity with the data reported by Pali and Mehta (2013) that number of capsule per plant and 1000 seed weight shows positive relations with seed yield.

The result also shows similarity with Foster et al. (1998), Payasi *et al.* (1999), Pal *et al.* (2000), Akbar *et al.* (2001), Gauraha *et al.* (2011), Kumar *et al.* (2013), Tadesse *et al.* (2016), Choudhary *et al.* (2017) and Ankit *et al.* (2019) which shows number of capsules per plant shows a significant association with seed yield.

Table 4.20: Genotypic correlation coefficient for seed weight per plant and component traits in linseed genotypes during 2020-21

	TPH	ST	EB	LL	DF	CW	CP	SL	SW	S	LF	SEYM	SFM	SWP
TPH	1													
ST	-0.71**	1												
EB	-0.47**	0.95**	1											
LL	-0.07	0.75**	0.9**	1										
DF	0.04	0.17	0.04	0.30**	1									
CW	-0.5**	0.86**	0.89**	0.83**	-0.28*	1								
CP	-0.74**	0.52**	0.09	0.15	-0.05	0.36**	1							
SL	-0.63**	0.83**	0.72**	0.70**	0.14	0.82**	0.57**	1						
SW	-0.69**	0.66**	0.52**	0.26*	-0.04	0.63**	0.63**	0.89**	1					
S	-0.85**	0.92**	0.93**	0.93**	-0.05	0.85**	0.85**	0.93**	0.86**	1				
LF	0.32**	-0.55**	-0.34**	-0.08	0.25*	-0.36**	-0.11	0.03	-0.14	0.15	1			
SEYM	0.52**	-0.72**	-0.44**	-0.23*	0.10	-0.38**	-0.38**	-0.22*	-0.43**	-0.23*	0.85**	1		
SFM	0.64**	-0.62**	-0.41**	-0.03	0.33**	-0.37**	-0.39**	-0.20	-0.45**	-0.06	-0.09	0.82**	1	
SWP	-0.7**	0.67**	0.54**	0.44	-0.24*	0.82**	0.95**	0.58**	0.54**	0.78**	-0.09	-0.23*	-0.28*	1

* Significant at 5% level, ** Significant at 1% level

TPH- Total plant height(mm)
ST- Stem thickness(mm)
EB-Epicotyl branching
LL-Leaf length(mm)

DF- Dia. of open flower(mm)
CW-Capsule width(mm)
CP-number of capsule per plant
SL- Seed length(mm)

SW- Seed width (mm)
S-1000 seed weight (g)
SWP- Seed weight per plant(g)
LF-Length of flowering

SEYM- Seedlings to early yellow maturity
SFM-seedlings to full maturity

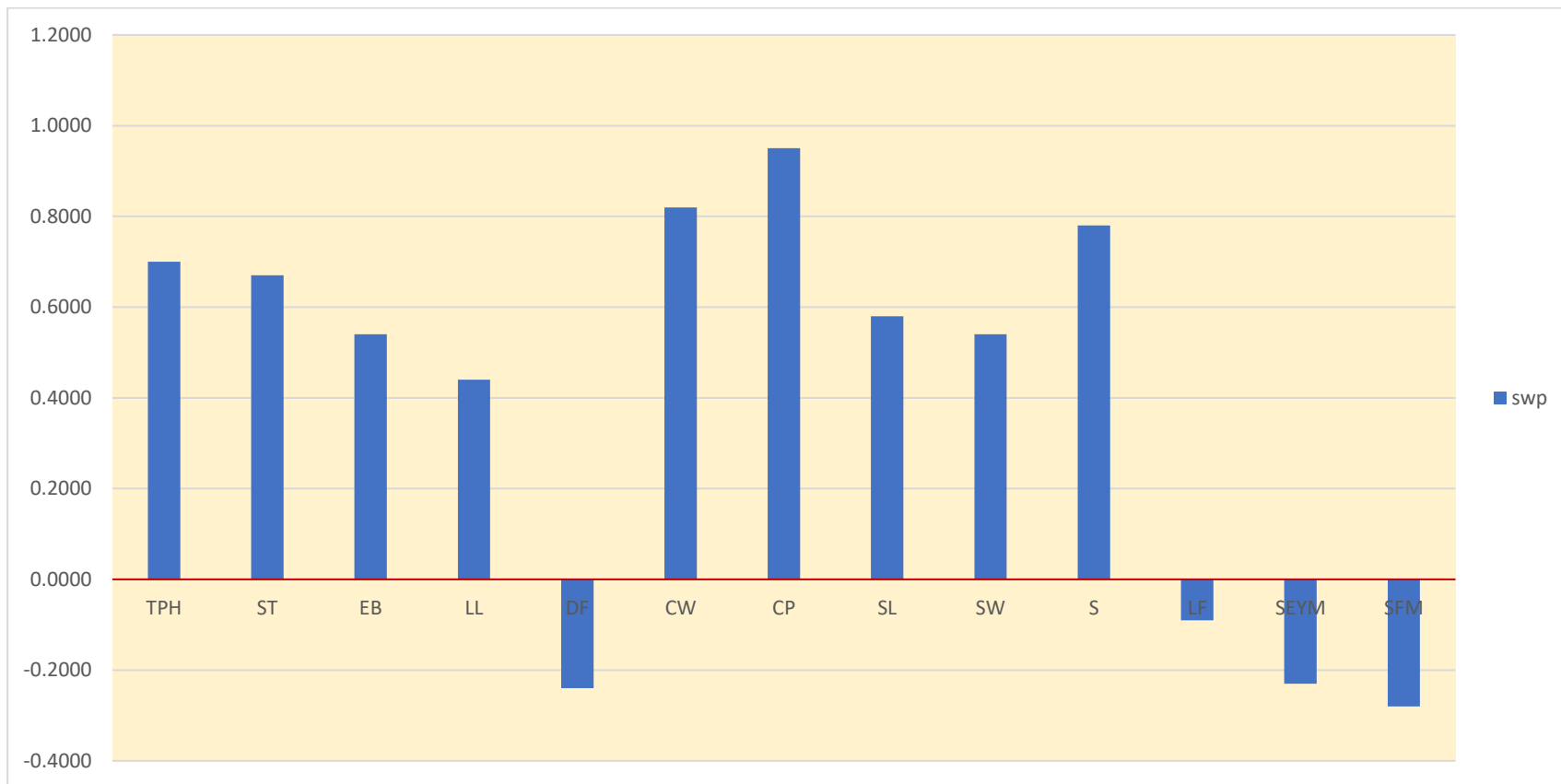


Fig 4.4: Genotypic correlation among seed weight per plant and its component traits in linseed genotypes during 2019-20 .

Table 4.21: Phenotypic correlation coefficient for seed weight per plant and component traits in linseed genotypes during 2020-21

	TPH	ST	EB	LL	DF	CW	CP	SL	SW	S	LF	SEYM	SFM	SWP
TPH	1													
ST	-0.17	1												
EB	-0.36**	0.43**	1											
LL	0.25*	0.34**	-0.04	1										
DF	0.02	0.02	-0.05	-0.02	1									
CW	-0.21	0.48**	0.24*	0.28*	-0.16	1								
CP	-0.36**	0.16	0.36**	-0.21	-0.15	-0.009	1							
SL	-0.23*	0.32**	0.09	0.09	0.10	0.32**	-0.05	1						
SW	-0.32**	0.39**	0.11	0.05	0.03	0.22	0.07	0.80**	1					
S	-0.14	0.28*	0.31**	0.04	0.10	0.29**	-0.03	0.41**	0.26*	1				
LF	0.08	-0.3**	-0.16	0.02	0.15	-0.03	-0.02	-0.17	-0.22	-0.04	1			
SEYM	0.20	-0.31**	-0.22*	-0.03	0.12	-0.12	-0.06	-0.16	-0.22*	-0.09	0.52*	1		
SFM	0.27*	-0.30**	-0.19	-0.01	0.24*	-0.07	-0.09	-0.12	-0.28*	-0.05	0.53**	0.73**	1	
SWP	-0.4**	0.38**	0.45**	-0.03	-0.16	0.36**	0.60**	0.28*	0.27*	0.58**	-0.16	-0.09	-0.11	1

* Significant at 5% level, ** Significant at 1% level

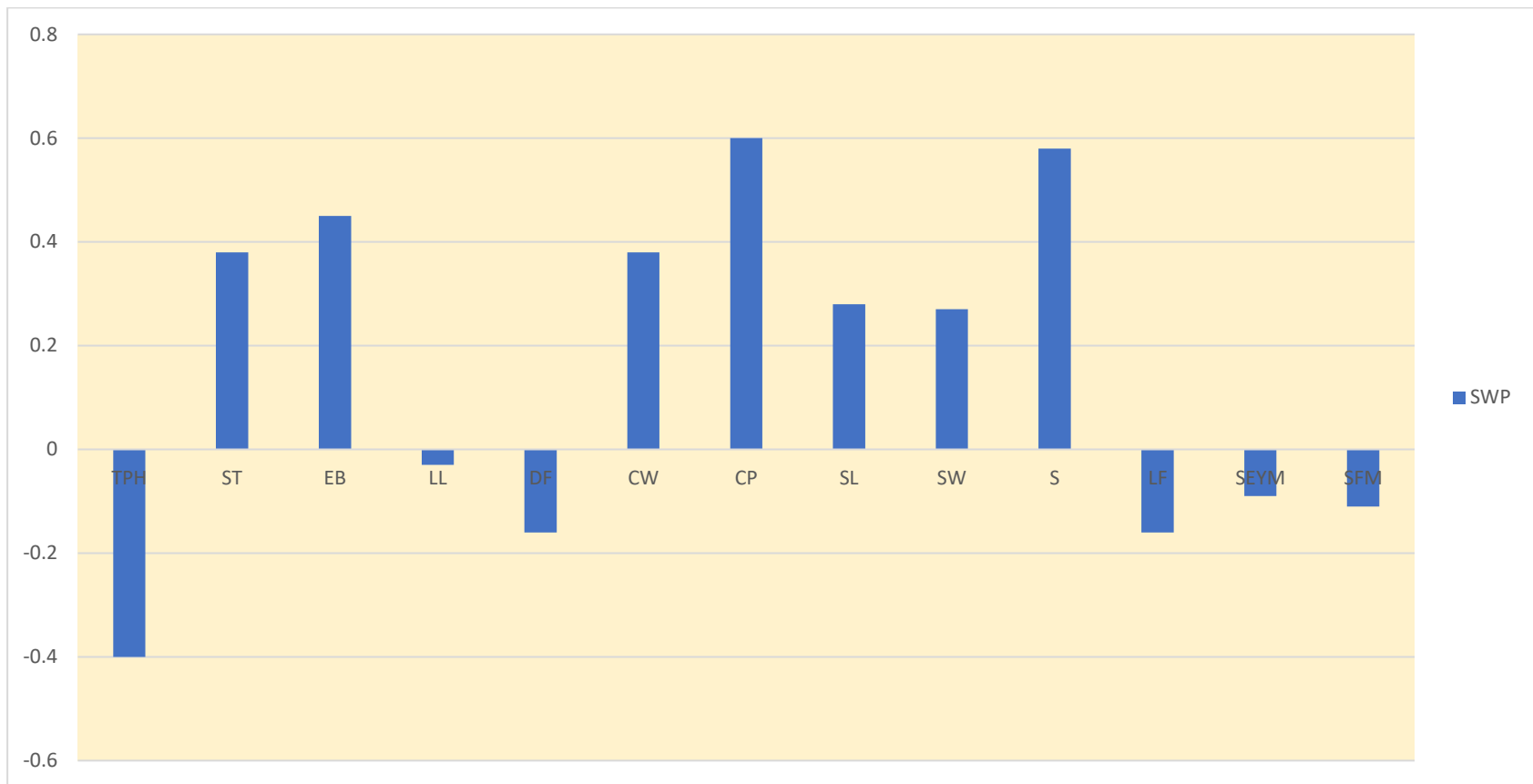


Fig 4.5: Phenotypic correlation among seed weight per plant and its component traits in linseed genotypes during 2020-21

CHAPTER-V

SUMMARY AND CONCLUSION

The present experiment was carried out entitled as “**MORPHOLOGICAL CHARACTERISATION OF LINSEED (*Linum usitatissimum* L.) GENOTYPES**” was conducted at Research cum Instruction farm, Department of Genetics and Plant Breeding, IGKV, Raipur, C.G during *rabi* 2020-21. The experimental materials included 26 linseed genotypes from the “AICRP on linseed, Department of Genetics and Plant Breeding, IGKV, Raipur”, Chhattisgarh, India, which include four check RLC-92, RLC-143 and RLC-148, RLC-151. The research work configured through Randomized Complete Block Design having three replications having 4m x 4m scale. For the diverse linseed genotypes, which shows similar growth habits and morphological characters a set of descriptors was developed, which allows for easy characterization as well as evaluation and identification by farmers and breeders at field level. Information on the extent and nature of inter-relationships between characteristics determine the extent of significant morphological variation, genetic variability, and association analysis for seed yield per hectare (Qt/ha) and its contributing factors across twenty-six linseed genotypes. The outcomes of the experiment can be summarized as below.

- ❖ According to DUS descriptor classification between twenty-six genotypes was carried out. For cotyledon shape 9 genotypes were included in class of oval, 10 genotypes in class of elliptical and 7 genotypes circular category.
- ❖ Based on anthocyanin colour of hypocotyl it was found that eighteen genotype contained anthocyanin and 8 genotypes do not have anthocyanin in their hypocotyl.
- ❖ Based on leaf colour six genotypes categorized as light green, thirteen genotypes categorized as green and seven genotypes belonged to dark green category.

- ❖ Based on inflorescence shape thirteen genotypes belonged to branchy, six genotypes belonged to moderately branchy and seven genotypes fall in the category of compact respectively.
- ❖ Based on petal colour one genotype fall in violet category, four genotypes in violet blue category, nine genotypes in light blue, eleven genotypes in blue and one genotype in the category of white respectively.
- ❖ Based on petal aestivation ten genotypes categorized as twisted, eight genotypes as semi twisted and eight genotypes in valvate category respectively.
- ❖ Based on petal venation colour five genotypes categorized as violet colour, twenty genotypes in blue colour and one genotypes in white colour respectively.
- ❖ Based on petal margin shape nine genotypes categorized as even, fourteen genotypes as crenate and three genotypes categorized as coarsely crenate category.
- ❖ For the character petal margin folding seventeen genotypes belonged to plain category, four genotypes into folded inward and five genotypes as into folded outward category respectively.
- ❖ Based on reproductive organ position fifteen genotypes belonged to anthers surrounds stigma closely, seven genotypes into anthers surrounds stigma openly, four genotypes as stigma below anther and and one genotype into stigma above anther category respectively.
- ❖ The character like stigma colour seventeen genotypes categorized as white stigma and nine genotypes as blue stigma likewise for style colour eighteen genotype fall under the category of white style and eight genotypes as blue style .
- ❖ For sepal termination fifteen genotypes belonged to longitudinally acute category and eleven genotypes belonged to acute category.
- ❖ For the character like capsule shape twelve genotypes categorized as globular, six genotypes as pressed and eight genotypes fall under the category of conical.

- ❖ For capsule shape of base sixteen genotypes belonged to the category of circular and ten genotypes into heart shaped category.
- ❖ Anthocyanin colour for stem, leaf and sepal was not found in any of the genotypes studied.
- ❖ Group of genotypes (RLC-148, RLC-153, RLC-161, RLC-164, RLC-167) having light blue flower and other overlapping characters can be differentiated from each other to certain degree by the characters like petal margin folding, reproductive organ position .
- ❖ An analysis of variance for all traits revealed that the presence of enough variability among the twenty-six linseed genotypes.
- ❖ The range for seed weight per plant varied in between 1.45g to 4.23g with the mean value of 2.58g per plant. The lowest value shown by RLC-184 and highest value shown by RLC-172.
- ❖ The highest genotypic coefficient of variation was observed for the character number of capsules per plant 33.87% followed by seed weight per plant 25.95% Whereas highest phenotypic coefficient of variation was shown by number of capsule per plant 34.44%, followed by stem thickness 20.36%.
- ❖ The highest heritability was observed for the trait number of capsules per plant followed by stem thickness. the lowest heritability was observed in leaf length 36.08%. The genetic advance as % of mean was found to be highest in number of capsules per plant 68.62% followed by seed yield per plant. The lowest value was observed in leaf length 6.4%.
- ❖ The strong significant and positive correlation between seed weight per plant and capsule per plant suggested that a high capsule per plant might indicate a higher seed yield. As a result, selection based on capsule per plant may be reliant on high seed yield for variety development.

CONCLUSION-

- ❖ Linseed morphological features were evaluated using DUS and found to have a high degree of distinctiveness for the character like petal colour, petal aestivations, petal margin shape petal margin folding, petal venation colour, inflorescence shape etc.
- ❖ The whole genotype can be grouped into broad class for the character like leaf colour, sepal terminations capsule shape of base etc.
- ❖ The character like capsule dehiscence and leaf anthocyanin colour showed uniformity in their expressions.
- ❖ An analysis of variance for all traits revealed that the presence of enough variability among the twenty-six linseed genotypes.
- ❖ Phenotypic variance was greater than genotypic variance which means environment play a significant role in the expression of genotypic characters.
- ❖ Selection of those character having high heritability would be rewarding for variety development programme.
- ❖ Positive and significant correlation between the required characters promote improvement in both the traits.

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APPENDIX

Meteorological data recorded during crop growth season (November2020 to march 2021)

Standard mean week	Maximum Temperature(°C)	Minimum Temperature(°C)	Rain fall (mm)	Relative Humidity I (%)	Relative Humidity II (%)	Vapour Pressure I (mm)	Vapour PressureII (mm)	Wind Speed (km/hr)	Evaporation (mm)	Sun shine(Hr)
44	31.8	17.4	0	82.4	29.5	13.9	10.3	2.2	3.5	7.7
45	30.3	12.5	0	86.7	27.8	10.7	8.6	2.0	3.3	8.5
46	32.6	18.9	0	86.5	37	15.6	13.6	2.8	3.5	8.4
47	30.9	15.9	0.05	87.4	34.8	13.4	10.9	2.8	3.3	7.4
48	28.6	14.6	0	81.4	35.1	11.1	9.9	3.9	3.2	6.2
49	30.6	11.8	0	88.8	30.4	9.9	9.6	1.2	3.1	7.2
50	30.1	15.8	0	86.2	38.1	12.5	11.4	2.4	2.8	3.7
51	27.6	10.2	0	87.1	27	9.4	7.08	2.4	2.8	4.9
52	28.4	10.2	0	87	27.5	8.7	7.7	1.8	3.0	4.8
1	29.6	13.8	0	84.8	32.1	10.8	9.3	2.2	2.8	3.2
2	31.1	16.3	0	78.4	30	11.5	9.6	2.3	3.2	3.8
3	30	11.7	0	83.1	24	9.3	7.6	2.5	3.4	6.1
4	31	14.1	0	80	35.5	10.4	11.5	2.6	3.4	3.3
5	28.1	10.3	0.65	81.1	22.7	8.4	6.4	2.8	3.4	6.8
6	30.0	10.6	0	77.5	20.4	7.9	6.1	2.5	3.9	9.4
7	31.4	14.9	0.14	79.5	40.5	11.2	12.1	2.8	3.6	3.5
8	30.9	14.5	0.2	81.4	29.8	11.1	9.7	2.7	3.8	7.3
9	35.8	15.6	0	68.5	16.2	10.1	6.8	3.1	6.0	9.5
10	36.2	17.2	0	64	21.1	10.4	9.1	3.4	6.1	8.2
11	34.6	19.4	0.8	75.7	26.5	13.7	10.4	3.3	5.1	5.9

RESUME

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