Selection criteria, selection parameters, future research needs and future research strategies for improvement in yellow sarson (*Brassica rapa* var. Yellow Sarson)

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**ABSTRACT**

The Oleiferous *Brassica* species, commonly known as rapeseed-mustard, are one of the economically important agricultural commodities. Rapeseed-mustard comprising eight different species viz., Indian mustard, toria, yellow sarson, brown sarson, gobhi sarson, karan rai, black mustard and taramira, are being cultivated in 53 countries spreading all over the globe. The oil and protein content varies from 37 to 49% and 22-28%, respectively. The rapeseed-mustard, which contributes nearly 80% of the total rabi oilseed production, is a vital component in edible oil sector. The rapeseed-mustard crops are diverse in their agro-climatic requirements and crop management practices. The production constraints facing each of the crops are also diverse in nature. The objective of raising domestic availability of edible oil can be realized only by increasing the productivity of these oilseed crops. Enhancing the production and productivity of the crop assumes significance, not only from the farmers’ viewpoint but also for the edible oil industry and other vertically and horizontally linked enterprises.

**KEYWORDS**

Selection Criteria, Selection Parameters, Rapeseed Mustard, Future Research

**HOW TO CITE THIS ARTICLE**


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Rapeseed-mustard is the third most important source of edible oil after soybean and oil palm. In India, it is commonly referred to as Sarson. It is an important cooking medium and dietary fat of the majority of northern, north-western, central, eastern and north-eastern states of India. It is also the most common medium of pickling and food preservation. Domestic production of edible oil has remained almost stagnant during last five years oilseed production in the country is facing several challenges related to biotic as well as abiotic stresses, natural resources, climate change and fragmented land holdings. In the World, India having 4th rank in area and production of rapeseed and mustard.

In India Uttar Pradesh having third rank after Rajasthan and Madhya Pradesh (Anonymous, 2017-18).

**Selection Criteria**

Yellow sarson in an important group of oilseed *Brassica* species. The following selection criteria should be used for the improvement of yellow sarson gremplasm.

**Days to 50% Flowering**

It is recorded as the period from the date of seed sowing to opening of the 50 per cent flower on the main raceme of the randomly taken plants.
Days to Maturity

Days to maturity is recorded on the basis of difference between dates of sowing to date when most of the siliquae on the plant turned yellowish.

Plant Height (cm)

The height of plant was recorded in cm from the base to top of the selected plants.

Length of Main Raceme (cm)

The height of main raceme is measured in centimeters from main branch, end of the secondary branch start in main raceme to the apex of the main raceme of the height.

Number of Primary Branches per Plant

Number of first order branches as primary branches arising on the main shoot are counted on each selected plant at the time of maturity.

Table 1. Area, Production and Productivity of Rapeseed and Mustard in World, India and U.P. during 2017-18.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>World</th>
<th>India</th>
<th>Uttar Pradesh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (mha.)</td>
<td>36.68</td>
<td>5.75</td>
<td>638.6</td>
</tr>
<tr>
<td>Production (mt)</td>
<td>71.42</td>
<td>6.80</td>
<td>719.6</td>
</tr>
<tr>
<td>Procutivity (kg/ha.)</td>
<td>19.74</td>
<td>1183</td>
<td>1127</td>
</tr>
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</table>

Table 2. Original gene sources for desirable quality traits.

<table>
<thead>
<tr>
<th>Character</th>
<th>Species</th>
<th>Genotypes</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low sinapine</td>
<td>B. compestris</td>
<td>Sv. Polish</td>
<td>Downey et al. (1969)</td>
</tr>
</tbody>
</table>

Table 3. Sources of various quality traits.

<table>
<thead>
<tr>
<th>Quality traits</th>
<th>Species</th>
<th>Donor</th>
</tr>
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<tbody>
<tr>
<td>High oleic acid (70.2%) with low erucic acid (&lt;2%)</td>
<td>Brassica rapa</td>
<td>PHOP-2-2 (IC-552726)</td>
</tr>
<tr>
<td>Low linolenic acid (3.03%)</td>
<td>Brassica rapa</td>
<td>PHOT-8-2-11 (IC-552726)</td>
</tr>
</tbody>
</table>

Biological Yield per Plant (g)

After harvesting, each selected plant is weighed and biological yield per plant in grams was recorded.

Harvest Index (%)

Harvest index is worked out by using the following formula:

\[
\text{Harvest Index} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100
\]

1000-Seed Weight (g)

1000-seeds are counted from the bulk yield of each treatment per replication and weighed in grams with the help of electronic balance.

Oil content (%)

The oil content (% seed weight) is estimated for three randomly drawn samples of each treatment in each replication by Nuclear Magnetic Resonance (NMR) method.
**Protein Content (%)**

The protein content (% de-oiled meal weight) is estimated for three randomly drawn samples of each treatment in each replication by determining the Nitrogen content using the Nuclear Magnetic Resonance (NMR) method and micro Kjeldahl N distillation and subsequent multiplication of the nitrogen content value by 6.25, the universally accepted protein content estimation factor.

Protein content (%) = Nitrogen content (%) x 6.25

**Seed Yield per Plant (g)**

The seeds are sun dried and yield per plant is recorded by weighing in grams with the help of electronic balance.

**Leaf Area Index (cm/m²)**

Leaf area index was calculated by using the following formula given below:

\[ \text{L.A.I.} = \frac{\text{Leaf area}}{\text{Ground area}} \]

It is also calculated as described by Watson (1947):

\[ \text{L.A.I.} = \frac{\text{leaf area in cm/plant}}{\text{number of plants/square meter/10000}} \]

**Relative Water Content (%)**

Relative water content of second leaf from top is determined by following formula:

\[ \text{RWC} (%) = \frac{\text{Turgid weight - Oven dry weight}}{\text{Fresh weight - Oven dry weight}} \times 100 \]

**Specific Leaf Area**

Specific leaf area is calculated as per

\[ \text{S.L.A} = \frac{\text{Leaf area per plant in cm}^2}{\text{Leaf dry weight (g.) }} \]

**Specific Leaf Weight**

Specific leaf weight is calculated by formulae given below:

\[ \text{S.L.W} = \frac{\text{Leaf dry weight (mg)}}{\text{Leaf area (cm}^2\text{)}}. \]

**Important Quality Criteria**

Rapessed-mustard cultivar contains very high level of erucic acid (45-60%) in oil and high level of glucosinolate (120-180 µ mole / g) in oil free meal.

High percentage of erucic is undesirable from nutritional point of view for human being and high glucosinolate in oil free meal is considered to be growth inhibiting factor and may lead to carcinogenic effect in animals when used as feed. The breeding programme for oil quality improvement in Rapeseed-mustard to reduced erucic acid content < 2% and glucosinolate contents < 30 µ mole / g in oil free meal. Pusa Karishma, Pusa Mustard-21 and RLC-2 varieties of Indian mustard has been released for zone II which having < 2% erucic acid.

**Selection Parameters**

**Variance Parameters**

The analysis of variance for the experimental design is based on the method suggested by (Panse and Sukhatma, 1967).

\[ P_{ijk} = (\mu + v_{ij} + r_k + e_{ijk} (ij = 1..... t; k = 1,......, r_i ) \]

where,

\[ P_{ijk} = \text{Phenotype of ijk}^{th} \text{ observation} \]

\[ \mu = \text{Population mean} \]

\[ v_{ij} = \text{Effect of i}^{th} \text{ progeny} \]

\[ r_k = \text{Effect of k}^{th} \text{ replication} \]

\[ e_{ijk} = \text{Error for e}_{ijk}^{th} \text{ observation} \]

**Variability Parameters**

Variability for different characters is estimated as suggested by (Burton, 1952). The coefficient of variability at genotypic (GCV), phenotypic (PVC), and environmental (ECV) levels were estimated as follows:

\[ \text{GCV} = \frac{\text{genotypic standard deviation}}{\text{mean}} \times 100 \]

\[ \text{PCV} = \frac{\text{phenotypic standard deviation}}{\text{mean}} \times 100 \]

\[ \text{ECV} = \frac{\text{environmental standard deviation}}{\text{mean}} \times 100 \]

**Combining Ability Parameters**

The analysis of variance for combining ability are carried out according to the method outlined by (Kempthorne, 1957), advocated general combing ability (gca) and specific combing ability (sca) in form of Covariance of half-sibs (H.S.) and Covariance of full-sibs (F.S.)

\[ \sigma^2 \text{ gca} = \text{Cov (H.S.)} \]

\[ \sigma^2 \text{ sca} = \text{Cov (F.S.) - 2 Cov. (H.S.)} \]
Where,
\[
\text{Cov (H. S.)} = \frac{(cm_1-m_3) + m_2-m_3}{r} + (f+m) \text{ Cov (H.S.)} - r \text{ (F+M) Cov (H.S.)} 3r
\]

\[
\text{Cov (F. S.)} = [m_1-m_4] + [m_2-m_4] + br\text{Cov (H.S.)} - r \text{ (F+M) Cov (H.S.)} 3r
\]

**Components of Variance Parameters**

\[
\hat{s}_g^2 = \frac{[m_1-m_3]}{fr}
\]
\[
\hat{s}_f^2 = \frac{[m_2-m_3]}{mr}
\]
\[
\hat{s}_g = \frac{[cm_1-m_3]}{r} + \frac{m_2-m_3}{r} (f+m)
\]
\[
\hat{s}_s = \frac{[m_3-m_4]}{r}
\]

Where,
\[
\hat{s}_g^2 = \text{Variance due to gca of males}
\]
\[
\hat{s}_f^2 = \text{Variance due to gca of females}
\]
\[
\hat{s}_g = \text{Variance due to gca}
\]
\[
\hat{s}_s = \text{Variance due to sca}
\]

**Average degree of dominances parameters**

The average degrees of dominance are calculated using the formula given by (Kempthorne and Curnow, 1961):

\[
\text{Degree of dominance} = \left[ \frac{\hat{s}_s^2}{\hat{s}_g^2} \right]^{0.5}
\]

\[
\hat{s}_s^2 = \text{Estimated variance due to sca}
\]
\[
\hat{s}_g^2 = \text{Estimated variance due to gca}
\]

**Heterotic Parameters**

It is estimated as per cent increase or decrease in the mean values of F$_1$ hybrid over superior and economic parents values.

Heterosis over economic-parents (%) = \[ \frac{F_1 - \text{E.P.}}{\text{E.P.}} \times 100 \]

Where,
\[
\bar{F}_1 = \text{Mean of F}_1 \text{ hybrid}
\]
\[
\text{E.P.} = \text{Mean of the economic-parent}
\]

Heterosis over superior-parents (%) = \[ \frac{F_1 - \text{S.P.}}{\text{S.P.}} \times 100 \]

Where,
\[
\bar{F}_1 = \text{Mean of F}_1 \text{ hybrid}
\]
\[
\text{S.P.} = \text{Mean of the superior-parent}
\]

**Inbreeding Depression**

The coefficient of inbreeding depression is calculated by the following formula:

\[
\text{Inbreeding depression} (%) = \left[ \frac{F_2 - F_1}{F_1} \right] \times 100
\]

Where,
\[
\bar{F}_1 \text{ and } \bar{F}_2 = \text{Mean of } F_1 \text{ and } F_2 \text{ generations, respectively.}
\]

**Heritability Parameters**

The heritability in narrow sense (h$^2$) was calculated as suggested by (Kempthorne and Curnow, 1961).

\[
\hat{h}^2 (%) = \frac{2 \hat{s}_g^2}{2 \hat{s}_g^2 + \hat{s}_s^2 + \hat{s}_e^2} \times 100
\]

Where,
\[
\hat{s}_g^2 = \text{Variance due to gca}
\]
\[
\hat{s}_s^2 = \text{Variance due to sca}
\]
\[
\hat{s}_e^2 = \text{Variance due to error}
\]

**Genetic Advance**

It is calculated using the following formula suggested by Allard (1960):

\[
G_s = (K) \cdot (\sigma \text{Ph}) \cdot (h^2)
\]

where,
\[
G_s = \text{The expectation of genetic advance under selection}
\]
\[
K = \text{Selection differential (2.06), a constant at 5 per cent selection intensity}
\]
\[
\sigma \text{Ph} = \text{The phenotypic standard deviation}
\]
\[
\hat{h}^2 = \text{The estimate of heritability coefficient in narrow sense}
\]

Genetic advance in percentage of mean is calculated as follows:

\[
G_s (%) = \left( \frac{G_s}{\bar{X}} \right) \times 100
\]

Where,
\[
G_s = \text{Expectation of genetic advance}
\]
\[
\bar{X} = \text{Mean of the character}
\]
\[
G_s (%) = \text{Genetic advance in percent over mean of the character}
\]

**Correlation Coefficient**

The formula of calculation of the genotypic and phenotypic coefficients of correlation are used as suggested by (Jibouri et al., 1958).
Selection criteria, selection parameters, future research needs and future research strategies for improvement in yellow sarson (Brassica rapa var. Yellow Sarson)

(a) Genotypic Correlation Coefficient
\[ r_{xy}(g) = \frac{Cov_{xy}(g)}{[V_x(g)V_y(g)]^{0.5}} \]

where,
Covariance \( xy(g) \) = Genotypic covariance between character \( x \) and \( y \) and this was computed as follows:
\[ Cov_{xy}(g) = [Cov_{xy}(p) - Cov_{xy}(e)]/r \]

\( V_x(g) \) and \( V_y(g) \) = Genotypic variance for the character \( x \) and \( y \), respectively

\( r \) = Number of replications

(b) Phenotypic Correlation coefficients
\[ r_{xy}(p) = \frac{Cov_{xy}(p)}{[V_x(p)V_y(p)]^{0.5}} \]

where,
Cov_{xy} (p) = Phenotypic covariance between character \( x \) and \( y \) and this was computed as follows:
\[ Cov_{xy}(p) = Cov_{xy}(g) + Cov_{xy}(e) \]

\( V_x(p) \) and \( V_y(p) \) = Phenotypic variance for the character \( x \) and \( y \), respectively

\( V_x(e) \) = The error variance for character \( x \) and \( y \), respectively.

Path Coefficients

The estimates of direct and indirect effects are calculated by path coefficient analysis as suggested by (Wright, 1921) and elaborated by (Dewey and Lu, 1959). The following set of simultaneous equations are formed and solved for estimating the various direct and indirect effects.

\[ r_{1y} = p_{1y} + p_{2y}r_{1.2} + p_{3y}r_{1.3} + \ldots + p_{14y}r_{1.14} \]
\[ r_{2y} = p_{1y}r_{2.1} + p_{2y} + p_{3y}r_{2.3} + \ldots + p_{14y}r_{2.14} \]
\[ r_{14y} = p_{1y}r_{14.1} + p_{2y}r_{14.2} + p_{3y}r_{14.3} + \ldots + p_{14y} \]

Where,
\( r_{1y} \) to \( r_{14y} \) = Correlation between 1 to 14 (Independent characters) and \( y \) (Dependent character).

\( p_{1y} \) to \( p_{14y} \) = Direct effect of characters 1 to 14 (Independent) on character \( y \) (Dependent).

\( p_{1y}, r_{1.2} \) to \( p_{15y}, r_{14.15} \) = Indirect effects of characters 1 to 14 on the dependent characters 1 to 14 represent the independent characters.

\( y = \) Seed yield per plant (Dependent character).

Replacing the corresponding elements in A and B matrix obtained the genotypic and phenotypic path coefficients by genotypic correlation coefficients or phenotypic coefficients. B matrix was inverted and the inverted B matrix was multiplied by a matrix to obtain path coefficients.

Residual Effects

Residual factor which measures the contribution of rest of the characters of the cancel scheme was obtained by using the following formula:-
\[ Residual factor (X), P_{xy} = \sqrt{(1 - R^2)} \]

Where,
\[ R^2 = \sum p_{xy}^2 + \sum j.p.P_{iy}.R_{ij} \] and \( 1>j \).

Future Research Needs

This is challenging, nevertheless it is possible to achieve the goal by adopting vertical and horizontal growth. Immediate research need for vertical growth would conventional breeding with emphasis on sustainability, genetic engineering of through exploitation of available genetic variability heterosis breeding should be the major focus. Furthermore, augmentation or identification of trait specific germplasms, pre-breeding and genetic enhancement, allele mining, proteomics, marker assisted breeding and gene pyramiding would facilitate better exploitation of the available gene pools in order to overcome the production constraints reducing the yield gap and additional area under cultivation are the viable approaches for horizontal growth.

Future Research Challenges

The major future research challenges are:

General Challenges
- Shrinking average land holding and water availability.
- Increase in CO2 concentration and temperature.
- Increased droughts, floods and heat waves.

Specific Challenges
- High temperature during crop establishment and terminal stage causes shortening of growing season.
- Fog and intermittent rains during crop growth.
- Mono cropping in most of the major areas.
- Depleting availability and deteriorating quality of water.
Future Research Strategies

The major future research strategies are follows:
1. Genetic enhancement and biotechnology
2. Heterosis breeding
3. Biotechnology interventions
4. Use of nano-technology
5. Natural resource management:
   (i) Crop diversification
   (ii) Improving input use efficiency
   (iii) Enhancing irrigation potential
   (iv) Biofertilizers and soil microbes
   (v) Farm mechanization
   (vi) Bio-risk management
   (vii) Post harvest and value addition
   (viii) Policies and reforms:
       • Institutions and policies
       • Market and trade reforms policies
   (ix) Capacity building and technology transfer
   (x) Human resource development
   (xi) Technology dissemination systems
   (xii) Marker Assisted Selection (MAS)
   (xiii) Resource conservation technology (RCT’s).

References


Anonymous (2017-18) Indian Institute of Rapeseed and Mustard Research, Bharatpur, Rajasthan, India.

