Acknowledgements

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**GENETIC RESOURCES**

**A bunchy genotype in Indian mustard (Brassica juncea)**

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**Abstract**

A field experiment was carried out to characterize 460 accessions of rapeseed-mustard germplasm. One accession of Indian mustard (IC 355399-A) was observed with bunchy siliquae type, borne in compact clusters. This trait is not reported earlier in Indian mustard. The seeds were grown and selfed continuously to develop pure lines from 2005-2013 and also evaluated for various agro-morphological traits to compare with national checks. This genotype had more number of siliqua (60-70/plant) than checks. Further, the genotype also showed superiority over normal varieties for yield related traits such as seed yield and number of primary branches etc. So, this unique germplasm can be utilized in national mustard improvement programme as donor for yield contributing traits.

**Key words:** Indian mustard, bunchy siliquae, agro-morphological traits

**Introduction**

The family Brassicaceae, is one of the ten most economically important plant families. The Indian sub-continent is an important source of diversity for Brassicas (Prakash and Hinata, 1980). The north-eastern and north-western regions hold promising genetic variability in oleiferous Brassicaceae. Rapeseed-mustard group comprising of six different species, viz., Indian mustard (Brassica juncea (L.) Czern. & Coss.), toria (B. rapa L. var. toria), yellow sarson (B. rapa L. var. yellow sarson), brown sarson (B. rapa L. var. brown sarson), gobi sarson (B. napus L.), karan rai (B. carinata Braun.) and black mustard (B. nigra (L.) Koch.). Indian mustard (Brassica juncea (L.) Czern and Coss.) occupies about 90% of total acreage under rapeseed-mustard cultivation in India (Singh, 1996; Singh and Sharma, 2007). In spite of coordinated efforts at national level, productivity of Indian mustard is quite low. One of the reasons for low productivity is the very narrow genetic base of the cultivars. So, there is need of continuous screening of germplasm to identify promising or trait-specific genotypes for use in national crop improvement programme.

**Material and Methods**

During rabi season, 460 accessions of rapeseed-mustard germplasm were grown in an augmented block design along with three check varieties at NBPG Experimental farm, New Delhi. In the germplasm, an accession of Indian mustard (IC 355399-A) collected from Fatehagarh district of Uttar Pradesh, medium-tall plants with prolific bearing siliquae borne in compact clusters were observed. Such bunchy genotype in Indian
mustard has not been reported earlier. Therefore, details of the plant were studied along with two check varieties of Indian mustard namely Varuna and Kranti at NBPGR Experimental Farm, New Delhi for two years. Flowers of this plant were bagged and selfed-seeds were harvested. Selfed seeds from bunchy plant were grown during 2005-2013 to develop pure line. Seeds of this bunchy mustard genotype have been supplied to different mustard research centres for evaluation and validation. Plants have been utilized in crossing programmes at Indian Agriculture Research Institute (IARI) New Delhi, Directorate of Rapeseed Mustard Research, Bharatpur (Rajasthan) and S.K. Rajasthan Agriculture University, Agriculture Research Station, Navgaon, Alwar (Rajasthan) for utilization in crop improvement.

Results and Discussion
The mutant plants multiplied from the selfed-seeds, also produced compact inflorescences, with siliquae in clusters. The plants were quite distinct from normal plant population of Indian mustard. It was observed to be a spontaneous mutant with distinct bunchy habit of inflorescence. Flowers as well as siliquae were borne in compact clusters (Fig. 1A & 1B). The bunchy genotype had compact inflorescence type with more number of siliquae (60-70 siliquae/ plant) as well as higher seed yield (8.2 g/ plant) as compared to the check varieties. On an average, bunchy type plants had more number of primary branches than Varuna and Kranti. The details of vegetative and reproductive traits of the genotype as well as two check varieties of Indian mustard have been given in Table 1.

Since there is a narrow genetic base of Indian mustard, the diverse bunchy habit can be useful in widening diversity of Indian mustard. The bunchy genotype showed superiority over normal varieties for yield contributing traits. These plant types can be utilized directly or indirectly for developing high yielding varieties/hybrids. This mustard genotype will be further characterized for identifying marker genes associated with this character which can be a useful material for basic/ academic research to study inheritance in Indian mustard. Because of compact and erect habit of the bunchy plants, there was no pod shattering and lodging of the plants at maturity. Thus, this plant type will be suitable for mechanical harvesting. Seeds of the bunchy genotype have been multiplied and supplied to different breeders for utilization in mustard improvement programme.

Acknowledgements
The authors are grateful to the Director, NBPGR, New Delhi for providing facilities to carry out studies. Thanks are also due to Sh. R.C. Yadav and Dr. Y.S. Rathi Technical Officers for recording data and technical assistance in field work.

References
Table 1. Comparative details of important agro-morphological traits of bunchy genotype *vis a vis* two check varieties of Indian mustard

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Character</th>
<th>Bunchy Genotype</th>
<th>Varuna</th>
<th>Kranti</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Plant height (cm)</td>
<td>115.2</td>
<td>129.9</td>
<td>134.5</td>
</tr>
<tr>
<td>2.</td>
<td>No. of primary branches/ plant</td>
<td>5.2</td>
<td>4.5</td>
<td>4.7</td>
</tr>
<tr>
<td>3.</td>
<td>Length of main fruiting branch (cm)</td>
<td>36.5</td>
<td>67.1</td>
<td>44.9</td>
</tr>
<tr>
<td>4.</td>
<td>Number of siliquae on main fruiting branch</td>
<td>69</td>
<td>26.8</td>
<td>21.6</td>
</tr>
<tr>
<td>5.</td>
<td>Number of seeds per siliqua</td>
<td>14.6</td>
<td>12.8</td>
<td>15.8</td>
</tr>
<tr>
<td>6.</td>
<td>Days to mean flowering</td>
<td>74</td>
<td>75</td>
<td>86</td>
</tr>
<tr>
<td>7.</td>
<td>Days to mean maturity</td>
<td>133</td>
<td>134</td>
<td>139</td>
</tr>
<tr>
<td>8.</td>
<td>Seed yield per plant (g)</td>
<td>8.2</td>
<td>7.2</td>
<td>7.5</td>
</tr>
<tr>
<td>9.</td>
<td>1000 seed-weight (g)</td>
<td>4.16</td>
<td>4.40</td>
<td>3.34</td>
</tr>
<tr>
<td>10.</td>
<td>Oil content (%)</td>
<td>35.88</td>
<td>36.90</td>
<td>38.15</td>
</tr>
</tbody>
</table>

Fig 1. Flowers (A) and siliquae (B) in bunchy genotype of Indian mustard
Gamma rays mutagenesis induced male sterility in rapeseed
(Brassica napus L.)


Nuclear Institute for Food & Agriculture (NIFA), P.O. Box 446, Peshawar 25000, Pakistan
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Abstract
Rapeseed hybrid breeding is yet to be established in Pakistan due to the lack of effective measures for
development of efficient male sterile lines. Induction of male sterility through mutation breeding can provide an
effective mean for hybrid seed production in rapeseed. An attempt was made to induce male sterility through
gamma rays mutagenesis in 10 rapeseed genotypes. Higher gamma doses induced more sterility while
genotype NR-28/09 was found most sensitive to gamma mutagenesis with highest number of sterile mutant
plants.

Introduction
For breeding of hybrid varieties in rapeseed, one of the most important materials is male sterile lines. 
Rapeseed is largely self-pollinated and androgynous crop and it is difficult to obtain hybrid by emasculation. 
Therefore, use of male sterile system is the most practical method in the production rapeseed hybrid seeds. 
Male sterile line could be found in nature or may be induced by mutation. In the present study male sterility was 
induced in rapeseed genotypes through seeds gamma mutagenesis.

Material and Methods
Five doses of 0, 1.0, 1.2, 1.4, and 1.6 K Gy of “gamma rays” were used to induce male sterility in 10 high 
yielding and locally adapted rapeseed genotypes.

Results and Discussion
Gamma mutagenesis successfully induced male sterility in rapeseed plants at all levels of irradiation. Induced 
variability for plant fertility was analyzed through induction of morphological mutations in male parts of flower 
structure in mutant and normal untreated plant populations. Gamma rays adversely affected the plant fertility in 
all genotypes that lead to the greater sterility. The highest sterility of 24.50% was induced by gamma 
mutagenesis in genotype NIFA/NR-2-1/09. Genotypes 04 K 12/13-10-1 and NIFA/NR-23/09 both produced 
23.45% sterile plants as compared to 2.12 and 1.77% sterile plants in respective control. The gamma rays 
reduced the general growth and development of rapeseed plants with increase in irradiation doses. While 
escalated sterility was observed in higher doses as compared to lesser gamma doses and un-treated 
rapeseed population.
Based on visual observation, gamma rays dose-wise field screening was exercised for the male sterility in all
M₂ plants of 10 rapeseed genotypes during flowering stage. Total 1516 plants containing or suspected to contain the sterile mutant allele were observed, identified and tagged. Highest number of mutant plants with distorted stamens was observed in genotype NR-28/09. Total 228 mutant plants were isolated with deformed stamens in all genotypes. Total 339 mutant plants with deformed flowers were observed for all 10 genotypes while maximum mutant plants of mutated flowers were registered in genotype NR-28/09. One hundred and thirty two plants with polycarpus flowers were also observed in segregating mutant population. Genotypes NR-21/09 and Punjab Sarsoon produced maximum number of such flowers (16 each). Gamma radiation also affected the whole morphology of rapeseed plants. Genotype NR-28/09 produced maximum number of mutant plants with changed ideotype as compared to rest of the genotypes.

References


Figure 1. Effect of gamma radiation doses on sterility (%) in rapeseed genotypes

<table>
<thead>
<tr>
<th>Genotype</th>
<th>0.0 kgy</th>
<th>1.0 kgy</th>
<th>1.2 kgy</th>
<th>1.4 kgy</th>
<th>1.6 kgy</th>
<th>Total</th>
</tr>
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<tr>
<td>Abasin-95</td>
<td>2.34</td>
<td>5.32</td>
<td>8.12</td>
<td>11.65</td>
<td>21.11</td>
<td>158</td>
</tr>
<tr>
<td>Durr-e- NIFA</td>
<td>2.69</td>
<td>5.32</td>
<td>9.89</td>
<td>10.56</td>
<td>28.06</td>
<td>165</td>
</tr>
<tr>
<td>Punjab Sarsoo n</td>
<td>1.33</td>
<td>5.36</td>
<td>10.07</td>
<td>14.99</td>
<td>20.08</td>
<td>144</td>
</tr>
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<td>NH 97-5/2-4</td>
<td>1.28</td>
<td>5.92</td>
<td>9.86</td>
<td>19.13</td>
<td>22.14</td>
<td>144</td>
</tr>
<tr>
<td>04 K 12/13-10-1</td>
<td>2.12</td>
<td>6.48</td>
<td>10.78</td>
<td>18.62</td>
<td>23.48</td>
<td>144</td>
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<td>Hyola-401</td>
<td>2.46</td>
<td>7.02</td>
<td>8.83</td>
<td>15.81</td>
<td>22.78</td>
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<td>8.82</td>
<td>9.51</td>
<td>17.82</td>
<td>24.5</td>
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<td>10.78</td>
<td>9.35</td>
<td>16.15</td>
<td>20.48</td>
<td>162</td>
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<tr>
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<td>1.77</td>
<td>8.83</td>
<td>7.79</td>
<td>14.80</td>
<td>28.48</td>
<td>172</td>
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<tr>
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<td>1.87</td>
<td>4.03</td>
<td>5.84</td>
<td>14.80</td>
<td>22.8</td>
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<table>
<thead>
<tr>
<th>Genotype</th>
<th>Deform stamen</th>
<th>Deform flower</th>
<th>Polycorpus flower</th>
<th>Changed ideotype</th>
<th>Total</th>
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<td>26</td>
<td>35</td>
<td>12</td>
<td>85</td>
<td>158</td>
</tr>
<tr>
<td>Durr-e- NIFA</td>
<td>30</td>
<td>37</td>
<td>13</td>
<td>85</td>
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<tr>
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<td>32</td>
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<td>139</td>
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<tr>
<td>NIFA/ NR-28/09</td>
<td>32</td>
<td>38</td>
<td>15</td>
<td>87</td>
<td>172</td>
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<tr>
<td>Total</td>
<td>228</td>
<td>339</td>
<td>132</td>
<td>817</td>
<td>1516</td>
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</tbody>
</table>
A note on the oldest material evidence of *Brassicaceae* in Near East and Europe

Aleksandar Mikić¹, Aleksandar Medović², Ana Marjanović-Jeromela¹, Sreten Terzić¹

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There are numerous archaeological sites in Near East where the remains of various genera and species of the family *Brassicaceae* were found. A general opinion is that the genera *Brassica* and *Sinapis* were domesticated rather early and that provided oil, flavourings and leaves for millennia. The earliest evidence for deliberate collecting of *Brassica* and *Sinapis* seeds and their possible use as food comes from the site Jerf el Ahmar in Syria, dated at 10th millennium BP (before present).

It is rather certain that the brassicas followed cereals, legumes and other domesticated plant species on their spreading in all directions from the Fertile Crescent. One of them was towards Europe, recently released from boreal climate after the end of the last Ice Age, via Asia Minor. Among the most significant archaeological sites for the brassica crop history is Çatalhöyük East, in modern Turkey, dated at 6200-6600 BC (Fig. 1, left). Here the seeds of both *Brassica* and *Sinapis* were used for extracting oil for daily use, as a spice and probably in ritual purposes (Fairbarn et al. 2007).

The most ancient remains of *Brassicaceae* in Europe are mostly from wild flora, dated in early or middle Neolithic. It is supposed that they were collected for various used, in a way repeating the process of domestication. Among numerous sites, it is noteworthy to mention the following ones:

• 4400-4000 BC. Le Chenet des Pierres, the valley of Bozel, France, *Brassica* and *Sinapis* (Martin et al. 2008)
• 3200 BC. Stare gmajne, Ljubljansko barje, Slovenia, *Brassica rapa* (Fig. 1, right, Tolar et al. 2010)
• 2930-2880 BC. Jevišovice, Kleiner Anzingerberg, Austria, *Brassica rapa* (Kohler-Schneider & Canappele 2009)

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Forage dry matter crude protein yield in the intercrops of spring-sown brassicas with legumes

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*Corresponding author: aleksandar.mikic@nsseme.com

Introduction
Intercropping may be considered a practice of growing of at least two different plant species at the same place and the same time. It is surely one of the most ancient agricultural practices (Hauggaard-Nielsen et al. 2011). One of the most traditional ways of intercropping in temperate regions is the one that includes cereals and annual legumes (Bedoussac & Justes 2010).

Quite little is known on intercropping brassicas with legumes, although certain recent results demonstrate multiple benefits for a brassica component, such as much easier uptake of less available nutrients due to a positive influence of its legume companion (Cortés-Mora et al. 2010).

The goal of this study was to examine the potential of intercropping autumn-sown brassicas with legumes for forage dry matter crude protein yield.

Material and Methods
A small-plot trial was performed in the seasons of 2011/2012 and 2012/2013 at the Experimental Field of the Institute of Field and Vegetable Crops at Rimski Šančevi, including eight intercrops of autumn-sown brassicas and autumn-sown annual legumes and their sole crops. The rapeseed (*Brassica napus* L. var. *napus*) cv. Jovana and the white mustard (*Sinapis alba* L.) cv. NS Gorica played the role of supporting crops for four legumes, namely pea (*Pisum sativum* L.) cv. Jantar, common vetch (*Vicia sativa* L.) cv. Perla, and grass pea (*Lathyrus sativus* L.) cv. Sitnica, acted as supported crops.

In both seasons, all intercrops and sole crops were sown in early March, at a double reduced rate in the intercrops than those in the sole crops: 20 viable seeds m⁻² for rapeseed and white mustard, 50 viable seeds m⁻² for pea and grass pea and 60 viable seeds m⁻² for common vetch. The brassicas were cut in full budding, while the annual legumes were cut in full bloom.

Forage dry matter crude protein yield (kg ha⁻¹) was determined in all intercrops sole crops. The land equivalent ratio (LER) for forage dry matter crude protein yield was calculated according to the following formula:

\[
LER = \frac{B_{IC}}{B_{SC}} + \frac{L_{IC}}{L_{SC}}
\]

where \(B_{IC}\) is the forage dry matter crude protein yield of a brassica component in an intercrop, \(B_{SC}\) is the forage
dry matter crude protein yield of a brassica component in its sole crop, \( \text{L}_{\text{IC}} \) is the forage dry matter crude protein yield of a legume component in an intercrop and \( \text{L}_{\text{SC}} \) is the forage dry matter crude protein yield of a brassica component in its sole crop.

The obtained results were processed by analysis of variance (ANOVA) with the Least Significant Difference (LSD) test.

**Results and Discussion**

There were significant differences in two-year average forage dry matter crude protein yield in both intercrops and sole crops, as well as in the two-year average values of LER (Table 1).

Among the sole crops, the highest forage dry matter crude protein yield was in grass pea (2045 kg ha\(^{-1}\)), while the lowest forage dry matter crude protein yield was in rapeseed (1067 kg ha\(^{-1}\)). Among the intercrops of forage brassicas and annual legumes, the average two-year average values of forage dry matter crude protein yield varied between 1114 kg ha\(^{-1}\) in the intercrop of white mustard and Narbonne vetch and 2201 kg ha\(^{-1}\) in the intercrop of white mustard and grass pea. The majority of both sole crops and intercrops of forage brassicas and annual legumes had higher average forage dry matter crude protein yield in comparison to the average values of grass pea, with 1457 kg ha\(^{-1}\) (Mikić et al. 2011), or lentil, with 641 kg ha\(^{-1}\) (Mihailović et al. 2012).

All the intercrops had the average two-year values of LER higher than 1 and thus proved to be economically reliable.

**Conclusion**

The spring-sown intercrops of forage brassicas with annual legumes proved to have a considerable potential for producing forage dry matter crude protein and thus be a source of quality forage in feeding ruminants. The next step should target the assessment of the optimal sowing ratio between these two botanically different components.

**Acknowledgements**


**References**


Table 1. Two-year average values of forage dry matter crude protein yield (kg ha\(^{-1}\)) and its land equivalent ratio (LER) in pure stands and intercrops of spring-sown brassicas and legumes at Rimski Šančevi for 2011/2012 and 2012/2013

<table>
<thead>
<tr>
<th>Sole crop / Intercrop</th>
<th>Brassica forage dry matter crude protein yield</th>
<th>Legume forage dry matter crude protein yield</th>
<th>Total forage dry matter crude protein yield</th>
<th>LER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapeseed</td>
<td>1067</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>White mustard</td>
<td>1183</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>99</td>
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</tbody>
</table>
AGRONOMY AND VARIETAL TRIALS

Intercropping spring-sown brassicas with cereals for forage production

Vojislav Mihailović1, Aleksandar Mikić1, Branko Ćupina2, Ana Marjanović-Jeromela1, Radovan Marinković1, Dalibor Živanov1, Ankica Kondić-Špika1, Nikola Hristov1, Srbislav Denčić1

1Institute of Field and Vegetable Crops, Maksima Gorkog 30, 21000 Novi Sad, Serbia
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Introduction
Numerous authors define intercropping as a practice of cultivating of at least two different cultivated plant species at the same place and time. It is also one of the oldest agricultural practices worldwide (Hauggaard-Nielsen et al. 2011).

One of the most traditional ways of intercropping for forage production in temperate regions is the one that includes annual legumes and cereals (Bedoussac & Justes 2010). However, this is often used for grain production, leaving a quite scarce knowledge on the possibility of its use in forage production.

This study was aimed at assessing the potential of intercropping various autumn-sown brassicas and cereals for forage production.

Material and Methods
A small-plot trial has been performed in the trial years of 2011 and 2012 at the Experimental Field of the Institute of Field and Vegetable Crops at Rimski Šančevi near Novi Sad. It included eight intercrops of autumn-sown brassicas with autumn-sown annual legumes. Two brassicas, namely (Brassica napus L. var. napus) and white mustard (Sinapis alba L.), were mixed with three cereals, oat (Avena sativa L.), barley (Hordeum vulgare L.) and common wheat (Triticum aestivum L. subsp. aestivum), respectively. All five species were sown as sole crops as well.

All six intercrops and all five sole crops were sown in the first week of March, at a double reduced rate in the intercrops in comparison to those in the sole crops, as a measure that would avoid an expensive sowing. The sole crops of two forage brassicas were cut in the stages of full budding and beginning of flowering, while the sole crops of three cereals were cut few days before spikes or racemes would have appeared. Six intercrops were cut when both a forage brassica or cereal component was in its own optimum stage, in both seasons happening at the same time.

Forage dry matter yield (t ha\(^{-1}\)) was determined in all six sole crops and their eight intercrops, while for the latter the corresponding land equivalent ratio for forage dry matter yield (LER) was calculated according to the
following formula:
\[ \text{LER}_{\text{FDMY}} = \frac{B_{IC}}{B_{SC}} + \frac{C_{IC}}{C_{SC}} \]
where \( B_{IC} \) is the forage dry matter yield of a brassica component in an intercrop, \( B_{SC} \) is the forage dry matter yield of a brassica component in its sole crop, \( C_{IC} \) is the forage dry matter yield of a cereal component in an intercrop and \( C_{SC} \) is the forage dry matter yield of a cereal component in its sole crop.

The research results were processed by analysis of variance (ANOVA) together with the Least Significant Difference (LSD) test.

Results and Discussion
There were significant differences in both two-year average values of forage dry matter yield in eight intercrops and six sole crops and the two-year average values of LER (Table 1).

The two-season average values of in sole crops varied between 6.9 t ha\(^{-1}\) in white mustard and 9.4 t ha\(^{-1}\) in barley. The highest average two-season forage dry matter yield among the intercrops of the spring-sown forage brassicas and cereals was in the intercrop of rapeseed and barley (10.2 t ha\(^{-1}\)), while the lowest average two-season forage dry matter yield among the intercrops of the spring-sown forage brassicas and cereals was in the intercrop of white mustard and common wheat (6.6 t ha\(^{-1}\)) and the intercrop of white mustard and oat (6.5 t ha\(^{-1}\)). The highest two-year average individual contribution in the total forage dry matter yield among brassicas was in rapeseed (3.9 t ha\(^{-1}\)) in the intercrop with oat. The highest individual contribution in the total forage dry matter yield among cereals was in barley (8.0 t ha\(^{-1}\)) when intercropped with rapeseed.

The intercrop of rapeseed and barley had significantly higher two-year average LER value (1.17) in comparison to the remaining seven intercrops, all of which had their two-year average LER values higher than 1. These results are similar to those obtained in the trials with mutual annual legume intercropping (Čupina et al. 2011) and intercropping annual legumes with cereals (Mihailović et al. 2011) in the same agroecological conditions.

Conclusion
The spring-sown intercrops of forage brassicas with cereals have a considerable potential for forage production and its use in feeding ruminants. It is notable that rapeseed has a better ability to compete with cereals when intercropped together. Among the remaining issues related to intercropping spring-sown brassicas with cereals the most important is forage quality.

Acknowledgements

References
Table 1. Two-year average values of forage dry matter yield (t ha\(^{-1}\)) and its land equivalent ratio (LER) in pure stands and intercrops of spring-sown brassicas and cereals at Rimski Šančevi for 2010/2011 and 2011/2012

<table>
<thead>
<tr>
<th>Pure stand / Intercrop</th>
<th>Brassica forage dry matter yield</th>
<th>Cereal forage dry matter yield</th>
<th>Total forage dry matter yield</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Rapeseed</td>
<td>7.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>White mustard</td>
<td>6.9</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>Oat</td>
<td>-</td>
<td>8.3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Barley</td>
<td>-</td>
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<td>-</td>
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<td>-</td>
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<tr>
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<td>7.4</td>
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<td>0.03</td>
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</table>
**AGRONOMY AND VARIETAL TRIALS**

Forage dry matter crude protein yield in the intercrops of autumn-sown brassicas with legumes

Aleksandar Mikić¹, Vojislav Mihailović¹, Branko Čupina², Ana Marjanović-Jeromela¹, Svetlana Antanasović², Sreten Terzić¹, Đorđe Krstić², Dalibor Živanov¹, Radovan Marinković¹

¹Institute of Field and Vegetable Crops, Maksima Gorkog 30, 21000 Novi Sad, Serbia  
²University of Novi Sad, Faculty of Agriculture, Department of Field and Vegetable Crops, Trg Dositeja Obradovića 8, 21000 Novi Sad, Serbia  
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**Introduction**

Intercropping may be regarded as a practice of cultivating at least two plant species at the same place and the same time. Intercropping is one of the oldest agricultural practices in the world (Hauggaard-Nielsen et al. 2011). One of the most traditional intercropping forms in temperate regions, such as Europe, is growing a mixture of cereals and annual legumes (Bedoussac & Justes 2010).

The knowledge on intercropping brassicas with legumes is not extensive and the literary resources are still rather limited. There are some recent and encouraging reports on multiple benefits for a brassica component, since its legume companion makes the uptake of less available nutrients much easier (Cortés-Mora et al. 2010).

This research was aimed at examining the potential of intercropping autumn-sown brassicas with legumes for producing forage dry matter crude protein yield.

**Material and Methods**

A small-plot trial was carried out in the seasons of 2011/2012 and 2012/2013 at the Experimental Field of the Institute of Field and Vegetable Crops at Rimski Šančevi. There were eight intercrops of autumn-sown brassicas and autumn-sown annual legumes: fodder kale (Brassica oleracea L. var. viridis L.) cv. Perast and the rapeseed (Brassica napus L. var. napus) cv. Zorica were supporting crops, while the pea (Pisum sativum L.) cv. NS Krmni, the common vetch (Vicia sativa L.) cv. NS Tisa, Hungarian vetch (Vicia pannonica Crantz) cv. Panonka and the hairy vetch (Vicia villosa Roth) cv. NS Viloza were supported crops. All six cultivars were also included in the trial as sole crops.

In both years, all intercrops and sole crops were sown in the last week of September, at a double reduced rate in the intercrops in comparison to those in the sole crops: 25 viable seeds m⁻² for fodder kale, 15 viable seeds m⁻² for rapeseed, 60 viable seeds m⁻² for pea and 75 viable seeds m⁻² for common, Hungarian and hairy vetches. The sole crops of the brassicas were cut in full budding, while the sole crops of the annual legumes were cut in full bloom. The intercrops were cut when either brassica or legume component reached these optimum stages.
Forage dry matter crude protein yield (kg ha\(^{-1}\)) was determined in all sole crops and intercrops, with the land equivalent ratio (LER) for forage dry matter crude protein yield calculated according to the following formula:

\[
\text{LER} = \frac{B_{IC}}{B_{SC}} + \frac{L_{IC}}{L_{SC}},
\]

where \(B_{IC}\) is the forage dry matter crude protein yield of a brassica component in an intercrop, \(B_{SC}\) is the forage dry matter crude protein yield of a brassica component in its sole crop, \(L_{IC}\) is the forage dry matter crude protein yield of a legume component in an intercrop and \(L_{SC}\) is the forage dry matter crude protein yield of a brassica component in its sole crop.

The research results were processed by analysis of variance (ANOVA) with the Least Significant Difference (LSD) test applied.

**Results and Discussion**

Significant differences in both two-year average forage dry matter crude protein yield in intercrops and sole crops existed, as well as in the two-year average values of LER (Table 1).

The average two-year average values of forage dry matter crude protein yield among the intercrops of forage brassicas and annual legumes ranged from 1012 kg ha\(^{-1}\) in the intercrop of rapeseed and Hungarian vetch to 1996 kg ha\(^{-1}\) in the intercrop of rapeseed and hairy vetch. Some of the intercrops of forage brassicas and annual legumes had higher forage dry matter crude protein yield than diverse annual legumes, such as grass pea (\(Lathyrus sativus\) L.), with an average value of 1457 kg ha\(^{-1}\) (Mikić et al. 2011). Hairy vetch had the highest average forage dry matter crude protein yield among the sole crops, with 1919 kg ha\(^{-1}\).

Most intercrops proved to be economic reliable, with the average values of LER higher than 1.

**Conclusion**

The autumn-sown intercrops of forage brassicas with annual legumes may be considered a good source of quality forage rich in protein in feeding ruminants. The future research should be aimed at studying more agronomic aspects, such as the optimal sowing ratio between these two components.

**Acknowledgements**


**References**


Table 1. Two-year average values of forage dry matter crude protein yield (kg ha\(^{-1}\)) and its land equivalent ratio (LER) in sole crops and intercrops of autumn-sown brassicas and legumes at Rimski Šančevi for 2011/2012 and 2012/2013

<table>
<thead>
<tr>
<th>Sole crop / Intercrop</th>
<th>Brassica forage dry matter crude protein yield</th>
<th>Legume forage dry matter crude protein yield</th>
<th>Total forage dry matter crude protein yield</th>
<th>LER</th>
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<td>-</td>
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<td>Pea</td>
<td>-</td>
<td>1720</td>
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<td>Common vetch</td>
<td>-</td>
<td>1611</td>
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<td>Hungarian vetch</td>
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<td>101</td>
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</table>
Intercropping autumn-sown brassicas with cereals for forage production

Aleksandar Mikić1, Branko Ćupina2, Vojislav Mihailović1, Ana Marjanović-Jeromela1, Sreten Terzić1, Svetlana Antanasović2, Snežana Katanski1, Dalibor Živanov1, Vladimir Aćin1

1Institute of Field and Vegetable Crops, Maksima Gorkog 30, 21000 Novi Sad, Serbia
2University of Novi Sad, Faculty of Agriculture, Department of Field and Vegetable Crops, Trg Dositeja Obradovića 8, 21000 Novi Sad, Serbia
*Corresponding author: aleksandar.mikic@nsseme.com

Introduction
In accordance with a majority of the definitions by various authors, intercropping could be considered a practice of growing of two or more different cultivated plant species or varieties at the same place and time and is most likely one of the most ancient agricultural practices (Hauggaard-Nielsen et al. 2011).
Among the most traditional intercropping systems in temperate regions, such as West Europe, is the mixture of annual legumes and cereals (Bedoussac & Justes 2010). Very little is known on the potential of intercropping brassicas and cereals for forage production.
The goal of this study was to assess the potential of intercropping various autumn-sown brassicas and cereals for forage production.

Material and Methods
A small-plot trial has been carried out in 2010/2011 and 2011/2012 at the Experimental Field of the Institute of Field and Vegetable Crops at Rimski Šančevi in the vicinity of Novi Sad. It included eight intercrops of autumn-sown brassicas with autumn-sown annual legumes. Two brassicas, fodder kale (Brassica oleracea L. var. viridis L.) and rapeseed (Brassica napus L. var. napus) were intercropped with four cereals, namely oat (Avena sativa L.), barley (Hordeum vulgare L.), triticale (×Triticosecale) spp.) and common wheat (Triticum aestivum L. subsp. aestivum). All six species, were also sown as sole crops.
In both years, all eight intercrops of forage brassicas and cereals and their six sole crops were sown in the last week of September, at a double reduced rate in the intercrops in comparison to those in the sole crops, in order to reduce the sowing costs. The sole crops of the forage brassicas were cut in the stages of full budding and beginning of flowering, while the sole crops of the cereals were cut just before spikes or racemes appeared. The intercrops were cut when either brassica or cereal component reached their own optimum stage. In both trial years, this happened concurrently.
Forage dry matter yield (t ha⁻¹) was determined in all six sole crops and their eight intercrops, while for the latter the corresponding land equivalent ratio for forage dry matter yield (LER) was calculated according to the
following formula:
LER = B_{IC} / B_{SC} + C_{IC} / C_{SC},

where $B_{IC}$ is the forage dry matter yield of a brassica component in an intercrop, $B_{SC}$ is the forage dry matter yield of a brassica component in its sole crop, $C_{IC}$ is the forage dry matter yield of a cereal component in an intercrop and $C_{SC}$ is the forage dry matter yield of a cereal component in its sole crop.

The obtained study results were processed by analysis of variance (ANOVA), applying the Least Significant Difference (LSD).

**Results and Discussion**

Significant differences existed at a level of 0.05 in both two-season average values of forage dry matter yield in both intercrops and sole crops, as well as in the two-season average values of LER (Table 1).

A two-season average value of the forage dry matter yield in the sole crop of fodder kale ($7.5 \text{ t ha}^{-1}$) was significantly higher in comparison to the results of a trial in the same environment, with $4.1 \text{ t ha}^{-1}$ (Čupina et al. 2010). The highest two-season average individual contribution in the total forage dry matter yield among forage brassicas was in fodder kale ($4.3 \text{ t ha}^{-1}$) in the intercrop with common wheat. The highest two-season average individual contribution in the total forage dry matter yield among cereals was in barley ($7.7 \text{ t ha}^{-1}$ and $7.6 \text{ t ha}^{-1}$) in the intercrops with rapeseed and fodder kale respectively.

The two-year average values of LER ranged from 1.02 in the intercrops of fodder kale with common wheat and rapeseed with oat to 10.9 in the intercrop of fodder kale and barley. A slight majority of the intercrops had the values of LER less than 1 and thus may be considered not economically reliable.

**Conclusion**

The intercrops of the autumn-sown forage brassicas and cereals may produce high forage dry matter and used as fresh forage in feeding ruminants. Some intercrops have a great potential for forage production. A detailed study on the quality of the forage dry matter in the intercrops of the autumn-sown forage brassicas and cereals is required along with other important issues.

**Acknowledgements**


**References**


Table 1. Two-year average values of forage dry matter yield (t ha\(^{-1}\)) and its land equivalent ratio (LER) in pure stands and intercrops of autumn-sown brassicas and cereals at Rimski Šančevi for 2010/2011 and 2011/2012

<table>
<thead>
<tr>
<th>Pure stand / Intercrop</th>
<th>Brassica forage dry matter yield</th>
<th>Cereal forage dry matter yield</th>
<th>Total forage dry matter yield</th>
<th>LER</th>
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<tr>
<td>Fodder kale</td>
<td>7.5</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>Rapeseed</td>
<td>6.9</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>Oat</td>
<td>-</td>
<td>9.2</td>
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<td>-</td>
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<td>Barley</td>
<td>-</td>
<td>10.4</td>
<td>-</td>
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<td>Triticale</td>
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<tr>
<td>LSD(_{0.05})</td>
<td>0.5</td>
<td>0.9</td>
<td>0.8</td>
<td>0.03</td>
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</table>
CRUCIFERAE NEWSLETTER Nr. 34

Instructions to the authors – 2014

Deadline for contribution submission: December 1st 2014

The current issue of the Cruciferae Newsletter (vol. 34) will be published online at the beginning of year 2015 from the Brassica website (http://www.brassica.info/info/publications/cruciferae-newsletter.php). Online process will ensure rapid publication of your contribution. Therefore, we should be grateful if you would, please, follow the instructions below.

1- All contributions should be written in English.

2- Authors should submit manuscripts only by email to cruciferaenewsletter@rennes.inra.fr. A manuscript file in Microsoft Word (or some other word processing format) is required. The manuscript file must be named as following: Full name of the first author_Year of submission.doc or .rtf.

3- As previously contributions must not exceed 2 pages, including tables, figures and photographs. Arial 10 character is expected with single spacing (please use the submission form below).

4- The heading of the paper must be written in boldface letters and must include the title (1st line), followed by the author names (lines below) and their address (3rd lines) with the email address of the corresponding author.

5- Tables, figures and photographs must be included in, or at the end of the text.

6- While submitting their contributions, authors should mention one of the listed topics that is the most relevant to their work (see the list below), in order to facilitate the editing process.

7- All papers are published on their author’s responsibility.

List of selected topics (please, choose one topic for submission)
- Agronomy and variety trials
- Genetic resources
- Breeding strategies
- Cytogenetics
- Developmental and reproductive biology
- Functional genomics: from model to crop
- General information on Brassica
- Genetic transformation and biotechnologies
- Genome analysis and markers
- Quantitative genetics
- Other topics (please give two keywords)
Submission form

SESSION

Title

Authors, corresponding author*

Address
*Corresponding author: email@email

Abstract
Abstract

Keywords
Keywords (optional)

Introduction
Introduction

Material and Methods
Material and Methods

Results and Discussion
One section or two different sections

References

Table 1. Title

Figure 1. Title