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Acknowledgements

The current issue of the Cruciferae Newsletter (vol. 31) is published online from the Brassica website (http://www.brassica.info/info/publications/cruciferae-newsletter.php). The present issue contains 18 contributions. Members of the editing board would like to acknowledge the authors for the quality of their contributions. For future issues, we would be gratefull if all the authors could read and follow carefully the author recommendations before submitting their manuscript, in order to facilitate the editing process. In particular, it is necessary to mention one of the listed topics that is the most relevant to the presented work (see the list at the end of the present issue).

Finally, we would like to thank all the members of the Brassica group of INRA-Agrocampus Ouest-Univ. Rennes1 for their constant support.

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A short note on the origin of the words *Rapa* and *Raphanus*

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Introduction

Turnip (*Brassica rapa* L. subsp. *rapa*) and radish (*Raphanus* L.) are ancient European crops, well-known from the historical records related to Hellenistic and Roman times. Despite the fact that the archaeological data and detailed archaeobotanical analysis of both taxa are scarce in comparison to other crops such as cereals and legumes, there are implications that both were domesticated in Eurasia much earlier (Lewis-Jones *et al.*, 1982). There are opinions that, due to a lack of material evidence, it is linguistics that may bring more light to the issue of their origin (Zohary and Hopf, 2000).

This brief study was aimed at determining the origin of the words *rapa* and *raphanus*.

Materials and Methods

With a kind assistance of the extensive etymological databases provided by the Evolution of Human Languages project at the Santa Fe Institute, the Proto-Indo-European roots related to *rapa* and *raphanus* were searched for. Their development was presented through their direct derivatives and modern descendants, supported by various printed and online dictionaries of contemporary European languages.

Results and Discussion

There is one single Proto-Indo-European root directly associated with both *rapa* and *raphanus*, namely **rāp-/-ē-*, originally denoting 'turnip' (Nikolayev, 2007). This root subsequently evolved into five known attested direct derivatives in Ancient Greek, Latin, Proto-Baltic, Proto-Germanic and Proto-Slavic, with each further evolving into numerous forms in its modern descendants (Fig. 1).

The Proto-Germanic root had specifically rich development, with extinct forms such as Old High German *rāba* and *ruoba*, Old Norse *rōfa*, Middle Dutch *roeve*, Middle High German *ruobe* and *rüebe* and Middle Low German *rōve*.

The diphthong *rh-* in the Ancient Greek word is considered irregular, possibly explaining the word as a borrowing the northern Indo-European languages (Nikolayev, 2007).

The existing words denoting turnip in modern Celtic languages, such as Breton *irvin* and Welsh *erfin*, could be the developments of the root **arbīno-*, also directly derived from the Proto-Indo-European **rāp-/-ē-*, although with insufficiently clarified evolution (Pokorny, 1959).

It is most likely that the words denoting turnip in Uralic languages were probably imported together with the crop itself both from the Baltic peoples, as witnessed by the Finnish *rapsi*, or from the Slavs, as attested with the Hungarian *repce*.

Conclusions

The existing linguistic evidence confirms that turnip and radish were known to the speakers of the Proto-Indo-European language in their original homeland in Pontic-Caspian steppe, as has already been demonstrated in the case of legumes and cereals. It is possible that the root **rāp-/-ē-* denoted both crops, that is, a leafy brassica crop with thick and edible root. This is also an additional testimony that the Proto-Indo-European society was one with developed agriculture, as well as that its descendants took both crops and the words denoting them to their new homes across the Europe.

Acknowledgements

The Ministry of Education and Science of the Republic of Serbia.

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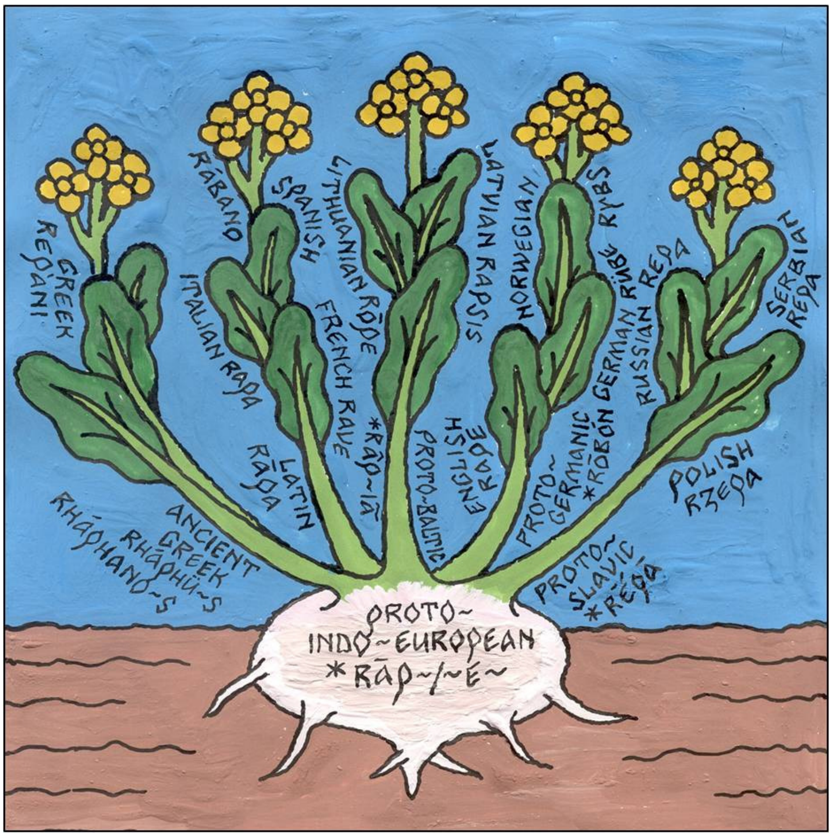

Figure 1. A symbolic evolution of the Proto-Indo-European root **rāp-/-ē-*

Genetic analysis of head color trait in Chinese cabbage

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Abstract

Brassica rapa species exhibits a wide variation in morphology. However, only a few genetic researches on this variation have been published. We bred an F_2 population (n = 188) derived from a cross between heading and semi-heading Chinese cabbages, and scored Head-Top-Color (*HTC*) trait. We constructed a linkage map to conduct quantitative trait locus (QTL) analysis, and detected a QTL for *HTC*. This information may be useful for breeding of Chinese cabbage with attractive color.

Introduction

Brassica crops are grown worldwide (e.g. broccoli, cabbage, Chinese cabbage, rapeseed and turnip). Among them, Chinese cabbage (*B. rapa*) is one of the most important vegetables especially in East Asia. The crop exhibits a wide variation in morphology. Many heading Chinese cabbages have the head fully wrapped by leaves. In contrast, semi-heading Chinese cabbage cultivar has a feature that the leaves curl outwards, exposing the yellow-colored head top. Recently, a gene locus for carotenoid accumulation at the inner leaves (*or*) was reported (Feng et al. 2011), but the relationship to the head top color is unknown. In this study, we describe the construction of a linkage map based on SSR markers, and the QTL analysis for the Head-Top-Color (*HTC*).

Materials and Methods

An F_2 population (n = 188) was made from a cross between a semi-heading type Chinese cabbage 'Kashin Hakusai' (Takii & Co., Ltd., Kyoto, Japan) and an ovate-heading type Chinese cabbage inbred line Y54 (Nippon Norin Seed Co., Tokyo, Japan), and two subsets (n = 94) were cultivated in 2010 and 2011, respectively. *HTC* was categorized by visual inspection using the following scales: 0 = green, 1 = yellow-green, 2 = yellow. Genomic DNA of each plant was extracted by CTAB method. SSR primers of *B. rapa* (Suwabe et al. 2006) were used for genetic analysis. Map construction and QTL analysis were performed as described previously (Kubo et al. 2010).

Results and Discussion

A distribution of *HTC* trait at the segregating generation did not show apparent discreet segregation (data not shown). This suggests that *HTC* was a quantitative trait. Accordingly, we performed QTL analysis related to its trait. A QTL with a large effect on *HTC* was detected on LG A09 in 2010 population (Fig. 1), which accounted for 30.0% of the phenotypic variation in this population. This QTL was located between BRMS-120 and BRMS-247, in which the QTL region above the LOD threshold was 3.8-32.0 cM. The peak position was at 23.7 cM, near BRMS-324, and its LOD score was 7.3 (Fig. 1, arrow). The allele of 'Kashin Hakusai' acted for yellow coloration. The QTL was reproductive in 2011, whose peak position was similar to that in 2010 (data not shown). The *HTC* QTL was located on the LG including the *or* locus (Feng et al. 2011). As a result of the search for *B. rapa* whole genome (The *Brassica rapa* Genome Sequencing Project Consortium 2011), sequences of syau15 and syau19 markers linked to the *or* were located around 36 Mb in LG A09, while BRMS-324 (*HTC*-linked marker) was >5 Mb apart from these sequences. This physical distance suggests that *or* and *HTC* were independent loci but their linkage cannot be ruled out. The present information could be useful for breeding of Chinese cabbage with different colors and shapes.

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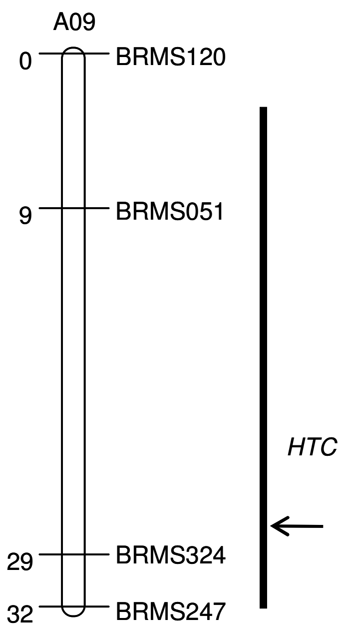

Figure 1. Linkage map and detected QTL in the F_2 population between 'Kashin Hakusai' x Y54 in 2010. A linkage group holding QTL is only shown. Map distances (cM), marker names and consensus linkage group number are shown on the left, right and top of the linkage group, respectively. A thick bar represents the QTL region detected. An arrow is the peak position of the QTL.

Genetic divergence in Indian mustard (*Brassica juncea* L. Czernj & Cosson)

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Abstract
Genetic divergence was estimated in 45 genotypes for characters by using Mahalanobis's D^2 statistic. The genotypes were grouped into six clusters. Cluster III had maximum intra-cluster distance while intra-cluster distance was highest between clusters IV and VI.

Key words: Genetic divergence, Indian mustard.

Introduction
Indian mustard (*Brassica juncea* L. Czernj & Cosson) is a highly priced oilseed crop and is cultivated either sole or as inter-crop under irrigated or rainfed condition in the Indian sub-continent. Genetic variation is essential for effective selection. In order to genetic variability, hybridization between genotypes of diverse origin is suggested to unlock new recombinations. Genetic divergence has been used as an indirect parameters of moderate effectiveness in selecting parental lines to produce high yielding progenies. Success of the hybridization followed by selection depends largely on the selection of parents with high genetic diversity for traits of interest (Murthy and Arunachalam 1966). Therefore, an effort was made to estimate the nature and magnitude of genetic diversity in a set of 45 genotypes of Indian mustard.

Materials and Methods
The experimental materials consisted of nine parents (RW873, PR830, Kranti, RW29-6-3, PR18, RH843, RH851, Vardan and BR40 were involved in a diallel mating design (excluding reciprocals). Forty-five genotypes were grown on three dates (E_1 and E_4 on 27th September, E_2 and E_5 on 4th October and E_3 and E_6 on 11th October 1997) at North-South (E_1, E_2 and E_3) and East-West (E_4, E_5 and E_6) sowing directions with two replications on each date during winter at Birsa Agricultural University experimental area, Ranchi. The area is located between 23°17" latitude and 85"19'E longitude and altitude is 625 meters above the mean sea level. The p^H of the soil is being 5.9. The distance between rows and plants were maintained at 30 and 10cm, respectively. Cultural practices as recommended for the area were followed. Ten competitive plants were randomly selected from each lines, replication and six environments to record the observations on 11 characters (Table 1). The replicated data were subjected to genetic divergence analysis using Mahalanobis's

D^2-statitic (Mahalanobis 1936) as suggested by Rao (1952). All the genotypes were grouped into respective clusters on the basis of D^2 values following Tocher's methods.

Result and Discussion

The analysis of variance revealed highly significant variation among the genotypes for all the traits studied. Individual character contribution towards divergence in Indian mustard varied fron 1.4141 (plant height) to 29.899 (Seed yield per plant). The different characters contributed to divergence *viz;* Days to maturity (23.5354), Oil content in per cent (11.9192) and Number of secondary branches per plant (10.303) Table 1. Similar result for number of secondary branches and seed yield per plant reported by Mahto (2004) in Indian mustard. These differences could be used in distinguishing genotypes on the basis of their morphology. Based on the D^2 analysis, all genotypes were grouped into six different clusters (Table 2). Cluster I was the biggest cluster having 16 genotypes (3 parents-RW29-6-3, RH851 and Vardan; and 13 crosses) and followed by cluster II having parent RW873 and eight crosses.

The average intra- and inter cluster D^2 values (Table 3) indicated that cluster IV with only one parent, namely RH843. The maximum intra-cluster distance (D^2 = 30.42) was observed in cluster III.

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Table 1. Individual character contribution towards divergence in Indian mustard.

Characters	Ranked first	% Contribution
Days to 50% flowering	27	2.7273
Number of primary branches per plant	32	3.2323
Number of secondary branches per plant	102	10.3030
Plant height (cm)	14	1.4141
Number of siliquae per plant	49	4.9495
Number of seeds per siliqua	24	2.4242
Days to maturity	233	23.5354
Harvest index	57	5.7576
1000 seed weight (g)	38	3.8384
Seed yield per plant (g)	296	29.8990
Oil content (%)	118	11.9192
TOTAL	990	100.0000

Table 2. Distribution of Indian mustard genotypes on the basis of D^2 statistic

Cluster	Number of genotypes	Genotypes
I	**16**	RW873xPR18, RW873xRH843, RW873xVardan, PR830xPR18, PR830xRH851, PR830xVardan, Kranti x RW 29-6-3, Kranti x PR 18, Kranti x Vardan, RW 29-6-3, RW 29-6-3 x PR18, RW 29-6-3 x BR40, RH843 x Vardan, RH851, Vardan, Vardan x BR 40
II	**9**	RW 873, PR830 x Kranti, Kranti x RH854, RW 29-6-3 x RH851, RW 29-6-3 x Vardan, PR18 x RH843, PR18 x Vardan, RH843 x BR40, RH851 x Vardan
III	**8**	RW873 x RH851, RW873 x BR40, PR830, PR830 x RW29-6-3, Kranti x RH843, RW 29-6-3 x RH843, PR18, BR40
IV	**1**	RH 843
V	**8**	RW873 x PR830, RW873 x RW29-6-3, PR830 x RH843, PR830 x Vardan, Kranti, PR18 x BR40, RH843 x RH851, RH851 x BR40
VI	**3**	RW873 x Kranti, Kranti x BR40, PR18 x RH851

Table 3. Average intra- and inter-cluster D^2 values for 45 genotypes of Indian mustard.

Cluster	I	II	III	IV	V	VI
I	22.02	57.91	83.86	998.27	249.42	557.78
II		24.72	212.39	1411.0	106.43	319.59
III			30.42	579.97	542.98	969.42
IV				0.0000	2166.4	2973.4
V					29.99	95.54
VI						29.04

Genetic Divergence and Stability Analysis in Indian mustard (*Brassica juncea* L. Czernj & Cosson)

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Abstract
Forty-five genotypes were grouped into six clusters on basis of Genetic divergence, which was estimated by using Mahalanobis's D^2 statistic. Cluster III had maximum intra-cluster distance while intra-cluster distance was highest between clusters IV and VI. The present RW 873 (cluster II) and crosses PR 830 x RH 851 (cluster I), RW 29-6-3 x RH 851 (cluster II) and RH 843 x BR 40 (cluster II) were found to be stable for seed yield per plant, test weight and oil content along with other yield attributes. Environment II was most favourable for yield and yield attributes.

Key words: Genetic divergence, environment-Interaction, stability, Indian mustard.

Introduction
Indian mustard (*Brassica juncea* L. Czernj & Cosson) is a highly priced oilseed crop and is cultivated either sole or as inter-crop under irrigated or rainfed condition in the Indian sub-continent. Genetic variation is essential for effective selection. In order to genetic variability, hybridization between genotypes of diverse origin is suggested to unlock new recombinations. Success of the hybridization followed by selection depends largely on the selection of parents with high genetic diversity for traits of interest (Murthy and Arunachalam 1966). In India, the major emphasis has been on increasing the seed yield and stability of lines to different agro-climatic conditions and, as such, the major breeding goals for thses crops have been centered oil yield, stability and wider adaptability. With these goals, the effort was made to estimate the nature and magnitude of genetic diversity and stable genotypes in a set of 45 genotypes of Indian mustard.

Materials and Methods
The experimental materials consisted of nine parents were involved in a diallel mating design (excluding reciprocals). Forty-five genotypes were grown on three dates (E_1 and E_4 on 27th September, E_2 and E_5 on 4th October and E_3 and E_6 on 11th October 1997) at North-South (E_1, E_2 and E_3) and East-West (E_4, E_5 and E_6) sowing directions with two replications on each date during winter at Birsa Agricultural University experimental area, Ranchi. The area is located between 23°17" latitude and 85"19'E longitude and altitude is 625 meters above the mean sea level. The p^H of the soil is being 5.9. The distance between rows and plants were

maintained at 30 and 10cm, respectively. Cultural practices as recommended for the area were followed. Ten competitive plants were randomly selected from each lines, replication and six environments to record the observations on 11 characters (Table 1). The replicated data were subjected to genetic divergence analysis using Mahalanobis's D^2-statitic (Mahalanobis 1936) as suggested by Rao (1952). All the genotypes were grouped into respective clusters on the basis of D^2 values following Tocher's methods. Stability analysis was done following Eberhart and Russell (1966).

Result and Discussion

The analysis of variance revealed highly significant variation among the genotypes for all the traits studied. These differences could be used in distinguishing genotypes on the basis of their morphology. Based on the D^2 analysis, all genotypes were grouped into six different clusters (Table 2). The average intra- and inter cluster D^2 values indicated that cluster IV with only one parent, namely RH843. The maximum intra-cluster distance (D^2 = 30.42) was observed in cluster III. PR 830 x RH 851 was stable for days to 50% flowering, plant height, number of siliquae per plant, number of seeds/ siliqua, days to maturity, 1000 seed weight, seed yield per plant and oil content (%) and belongs to cluster I. RW873 x RH851 (cluster III), Kranti x RW 29-6-3 (cluster I) and RH843 x BR40 (cluster II) were stable for eight yield and yield traits Table 1. Environment II was most favourable for yield and yield attributes and followed by environment V and VI Table 3.

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Table 1. Stability in Indian mustard for different characters over environments.

Crosses	1	2	3	4	5	6	7	8	9	10	11
CLUSTER I											
RW 873 x PR 18				*	*		*				
RW 873 x RH 843			*	*		*					
RW 873 x Vardan	*		*		*			*		*	
PR 830 x PR 18	*		*	*	*		*			*	
PR 830 x RH 851	*			*	*	*	*	*	*	*	*
PR 830 x Vardan		*		*		*		*		*	
Kranti x RW 29-6-3	*	*		*		*	*	*	*		*
Kranti x PR 18	*	*	*	*				*			*
Kranti x Vardan	*	*		*	*		*	*		*	
RW29-6-3	*			*			*		*	*	
RW 29-6-3 x PR 18	*			*			*	*	*		
RW 29-6-3 x BR 40	*	*				*		*	*	*	*
RH 843 x Vardan	*					*		*	*	*	
RH 851	*	*		*	*	*		*	*		
Vardan	*		*	*		*	*	*	*		
Vardan x BR 40			*	*		*			*	*	
CLUSTER II											
RW 873	*	*	*						*	*	*
PR 830 x Kranti	*		*				*				
Kranti x RH 851		*	*	*			*		*		
RW 29-6-3 x RH 851	*				*	*	*		*	*	*
RW 29-6-3 x Vardan		*		*	*		*	*		*	*
PR 18 x RH 843	*			*			*	*	*	*	
PR 18 x Vardan	*	*					*				
RH 843 x BR 40		*	*	*	*	*			*	*	*
RH 851 x Vardan			*		*						
CLUSTER III											
RW 873 x RH 851	*	*		*	*		*	*		*	*
RW 873 x BR 40						*	*	*		*	
PR 830	*		*	*	*	*	*		*		
PR 830 x RW 29-6-3	*		*	*	*	*			*		
Kranti x RH843		*	*	*			*		*		
RW 29-6-3 x RH 843	*	*		*	*		*	*	*		
PR 18	*			*	*		*		*		
BR 40	*	*	*					*		*	
CLUSTER IV											
RH 843	*	*		*	*		*				
CLUSTER V											
RW 873 x PR830		*					*				
RW 873x RW29-6-3				*				*			*
PR 830 x RH 843	*			*			*		*		
PR 830 x BR 40											*
Kranti	*	*			*		*	*	*	*	
PR 18 x BR 40	*		*	*		*		*		*	*
RH 843 x RH 851	*	*		*	*	*	*		*		
RH 851 x BR 40	*	*		*							*
CLUSTER VI											
RW 873 x Kranti			*	*						*	
Kranti x BR 40		*	*				*				*
PR 18 x RH 851	*	*	*	*	*		*			*	*

* is stable genotype for environments and Characters:-1.Days to 50% flowering, 2.Primary branches / plant, 3.Secondary branches /plant, 4.Plant height (cm), 5.Number of Siliquae/plant, 6. Number of Seeds/siliqua, 7.Days to maturity, 8.Harvest index, 9.1000-Seed weight (g), 10.Seed yield/plant (g) and 11.Oil content (%).

Table 2. Average intra- and inter-cluster D^2 values for 45 genotypes of Indian mustard.

Cluster	I	II	III	IV	V	VI
I	22.02	57.91	83.86	998.27	249.42	557.78
II		24.72	212.39	1411.0	106.43	319.59
III			30.42	579.97	542.98	969.42
IV				0.0000	2166.4	2973.4
V					29.99	95.54
VI						29.04

Table 3. Environmental index of different characters in Indian mustard over environments

Character	Environments					
1	-3.422	-8.344	6.744	2.644	-6.833	9.211
2	-0.258	-0.036	-0.402	-0.247	0.342	0.600
3	0.215	1.441	-0.252	-0.367	-0.674	-0.363
4	-1.070	6.407	-6.493	-14.526	10.974	4.707
5	-32.04	5.187	-28.16	-53.969	26.776	82.198
6	-0.560	0.547	-0.488	0.143	0.985	-0.626
7	-1.511	-8.211	6.311	1.456	-6.756	8.711
8	-0.010	0.027	0.002	-0.013	0.009	-0.017
9	-0.092	0.137	-0.015	-0.208	0.070	0.109
10	-0.987	0.005	-1.522	-1.861	2.023	2.342
11	0.060	0.445	0.354	0.282	-0.168	-0.974

Characters:-1.Days to 50% flowering,

2.Primary branches / plant, 3.Secondary branches /plant, 4.Plant height (cm), 5.Number of Siliquae/plant, 6. Number of Seeds/siliqua, 7.Days to maturity, 8.Harvest index, 9.1000-Seed weight (g), 10.Seed yield/plant (g) and 11.Oil content (%).

Allelopathic influence of Malabar nut (*Adhatoda vasica* Nees.) on turnip (*Brassica rapa* L.) : III. Root weight and days to flower

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Abstract

Aqueous leaf and flower extracts of *Adhatoda vasica* Nees. had stimulating effect on root weight of turnip (*Brassica rapa* L.) in M_1 generation, particularly at the lower doses. Contrary to this, there was gradual delay in the time of flowering from lower to higher doses in M1 generation. Some earliness in this regard was noted in M2. Increase in root weight, associated with late flowering, is beneficial from agricultural point of view in turnip.

Key words: allelopathy, *Adhatoda*, extract, turnip, root weight, flowering, dose.

Introduction

Allelopathy refers to the beneficial and harmful effects of one plant on another plant(s) growing in vicinity, both crop and weed species, by the release of chemicals from plant parts through leaching, root exudation, volatilization, residue decomposition and other processes in both natural and agricultural systems (1, 7, 12, 13). Biochemical interactions occur when the allelochemicals (secondary plant metabolites) produced by one plant escapes into the environment and influence the survival, growth and development of another plant growing nearby (5, 8, 9, 16, 17). Malabar nut (*Adhatoda vasica* Nees.), of family Acanthaceae, is a small evergreen, perennial shrub growing throughout the Indian peninsula up to an altitude of 1300 m on wastelands in a variety of habitats and types of soil. The plant parts have been used extensively in Ayurvedic medicine for over 2000 years primarily for respiratory disorders.Leaf juice is given in chronic bronchitis, asthama, dysentery and diarrhea. A paste of the leaves is applied to the abdomen to treat urinary disorders. It has been used by European herbal practitioners as an antispasmodic, expectorant and febrifuge. Besides it is used in treating diseases like abscesses, anthrax, tuberculosis, jaundice, scabies, pneumonia and urticaria. Extensive researches have been done on agricultural crops for getting superior varieties for obtaining more yield, disease resistance and quality improvement, but virtually no works have been done to investigate the allelopathic influence of medicinal plants on survival, growth and development of our valuable crops. Keeping this in view, present work was carried out to know the allelopathic impact of Malabar nut (*Adhatoda vasica* Nees.) on root weight and days to flower of turnip (*Brassica rapa* L.).

Material and methods

'Purple Top White' cultivar of turnip constituted the material for present investigation. To make the leaf and flower extracts, a field grown malabar nut plant was selected and 250 g mature leaves and flowers were detached from this separately. The leaves and flower samples were dried separately at 60° C. Then they were grinned to pass through 1 mm screen and stored at room temperature. Sterilized distilled water was used to make the leaf and flower extracts separately in 50: 1 (V/W) water: sample ratio. After this, it was kept in refrigerator for 18 hours. Now the suspension was centrifuged at 1000g for 15 minutes and then vacuum filtered through 0.4 µm polycarbonate filter to obtain the mother solution, and from this the solutions of different concentrations (20, 40, 60, 80 and 100 %) were made by adding required amount of distilled water. 300 turnip seeds were treated in each concentration for a period of 24 hours. For control, the seeds were soaked in distilled water only. Then the treated seeds were thoroughly washed in double distilled water and sown immediately in different pots of equal size having homogenous soil, along with Control to raise M_1 plants. M_2 populations were grown from the seeds collected from M1 through selfing. 30 randomly selected plants in each concentration and control, under both kinds of treatment, were pulled out from the soil just before the emergence of flowering shoot and their weight was taken separately with the help of a single pan balance to score mean root weight. Additional plants were grown for this purpose. The appearance of the first flower and its difference from the date of sowing gave the number of days to flower in each case. The treatments were replicated four times in Complete Randomized Design. The data were analyzed statistically using Critical Difference (C D) at 5% level of significance. All the results are presented in Table 1.

Results and discussion

The aqueous leaf and flower extracts of A*dhatoda vasica* exhibited stimulating effect on root weight of turnip. There was gradual increase from 20% to 60% concentration, followed by a sharp decline at 80% and 100% in M_1 generation. Maximum stimulation was noted at 60% concentration under both kinds of treatment. Noticeably a further increase took place in M_2 at all the doses under both kinds of treatment. Remarkably the leaf extract treatment demonstrated more stimulating effect than the flower extract treatment at all the used concentrations. Contrary to this, gradual delay in the time of flowering was observed from lower to higher doses under both kinds of treatment in M_1 generation. Some earliness in this regard was noted in M_2 under both kinds of treatment at all the doses.

Molisch (7) coined the term ‘allelopathy’ which refers to all stimulatory and inhibitory biochemical interactions between the plants including microbes. The allelopathic plants control the environment in which they live. Allelopathy is one of the triggers for succession of vegetation in a natural ecosystem.The medicinal plants have strong allelopathic potential (2, 3, 9, 10, 11, 12).Vasicine is the major alkaloid present in all parts of the plant body of A*dhatoda vasica*. The leaves also contain vasicinone, 7- methoxyvasicinone, vasicinol, adhatodine, adhatonine, adhavasinone, anisotine, 3- hydroxyanisotine, desmethoxyaniflorine, vasicoline, and vasicolinone 6-9 and essential oil. The flowers contain b- sitosterol – D –glucoside, kaempferol, glycoside, kaempferol and and queretin. Under present investigation biochemical interactions occurred when the allelochemicals present in the leaf and flower extracts of malabar nut came in contact with the embryo of seed during treatment which ultimately influenced the growth and development of the turnip plants raised from the treated seeds. At present it is difficult to ascertain out of the various constituents present in the leaf and flower extracts which one, or a group of these, is causal factor for inhibition or stimulation of the concerned traits of turnip. Obviously, it requires further biochemical investigations.

Moderately higher doses of the leaf extract of periwinkle (*Catharanthes roseus* Don.) exhibited stimulating effect on root weight of turnip (11). Carrot weed (*Parthenium hysterophorus* L.) leaf and flower extracts had inhibitory effect on root weight of turnip (12). The lower doses of the leaf extract of neem (*Azadirachta widica* A. Juss.) and azadirachtin – base biopesticide had inducing effect on root weight of *Brassica rapa* L., but their higher doses were harmful (6, 10). The crude neem oil treatment exhibited inducing effect on root weight of turnip (10). *Ocimum sanctum* L. and *O. canum* Sims. extracts had stimulating effect on root weight of turnip (3). However, all the above mentioned treatments caused delay in the time of flowering (3, 10, 11, 12, 14).

A*dhatoda vasica* is a medicinal plant and it is invariably believed that the medicines of plant origin are safe and can be consumed without any special care, but it is not so. Sometimes they have serious side effects (14). A*dhatoda* – based medicines and extracts too, may be toxic. Hence their use in large amount, particularly at higher concentrations, may prove hazardous. Theophrastus (1493-1541), regarded by many as the father of toxicology, is after paraphrased to have said "All things are poison and nothing is without poison; only the dose makes a thing poison." With this statement, he considered the apparent safety of toxicants at low doses. Moreover, some substances, although toxic at higher doses, can be stimulatory or even beneficial at low doses. This is the case with compounds such as pharmaceuticals that are used for their beneficial effects, as well as with compounds such as pesticides which are normally used as toxicants. This stimulatory effect of a low dose of a toxicant is called **hormesis**. Although this phenomenon was recognized earlier, the term hormesis was first used by Southam and Erlich (15) to describe the effect of an Oak bark compound that promoted fungal growth at low doses, but strongly inhibited it at higher doses. They coined this term using the Greek word 'hormo' (to excite), the same root used in the word hormone. It appears that *Adhatoda vasica* biosynthesizes several secondary metabolites that, once released from plant material, act jointly as allelochemicals in mixture. Probably hormesis is pronounced with mixture of allelochemicals (4) The developmental stages of the allelopathic plant species also play important role in eliciting a hormetic response (4, 12). The term 'allelopathy' is relatively new, but the concept is quite old. It is expected that in near future the knowledge of allelopathy will play a vital role in crop production, agroforestry and horticulture in developed as well as developing countries. Besides it has potentiality to emerge as one of the strategic sciences to reduce the environmental pollution. The rich plant diversity in India offers a significant opportunity for future research in this field.

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Table 1. Effect of *Adhatoda vasica* extracts on root weight and days to flower of turnip.

Dose (%)	Root weight (g)				Days to flower			
	Leaf extract		Flower extract		Leaf extract		Flower extract	
	M_1	M_2	M_1	M_2	M_1	M_2	M_1	M_2
Control	208.8	206.8	206.9	207.1	109.0	108.0	109.0	110.0
20	216.1 (+5.5)	220.2 (+6.5)	212.8 (+2.8)	216.4 (+4.5)	112.7 (+3.2)	109.7 (+1.4)	108.7 (-0.3)	106.0 (-3.2)
40	228.6 (+11.6)	230.3 (+11.4)	224.5 (+8.5)	227.6 (+9.9)	114.0 (+4.4)	112.0 (+3.5)	113.0 (+3.7)	112.0 (+2.3)
60	245.4 (+19.8)	249.0 (+20.4)	242.4 (+17.1)	245.4 (+18.5)	117.7 (+7.8)	114.7 (+6.0)	114.2 (+4.8)	111.2 (+1.6)
80	107.4 (-47.5)	107.3 (-48.1)	107.4 (-48.1)	136.3 (-34.2)	121.2 (+10.9)	119.2 (+10.2)	119.0 (+9.2)	117.2 (+7.0)
100	73.9 (-63.9	76.1 (-63.2)	67.5 (-67.4)	71.4 (-65.5)	125.7 (+15.1)	123.7 (+14.3)	122.7 (+12.6)	120.7 (+10.2)
CD at 5%	5.74	7.01	5.43	5.65	1.66	0.98	1.49	1.46

Data in parenthesis indicate percent stimulation (+) / inhibition (-) over control.

Study on yield and quality characters in cabbage seed obtained in the conditions of organic trial

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Abstract

The experiment was performed in the period 2006-2008 in the Maritsa Vegetable Crops Research Institute, Plovdiv with head cabbage open pollinated variety Balkan in the conditions of organic and conventional experiment for two year cycle of plant development and pollination in isolated facilities.The purpose of the study was some parameters of yield and quality in head cabbage seed obtained in the organic experiment conditions to be established.

It was established that in head cabbage reproduction in isolation facilities of the organic experiment the individual seed productivity 7.90 g/plant is lower compared to that recorded for the control variant. The absolute weight of the obtained organic seeds is lower – 3.50 g but the germinating ability of the organic seeds is high after harvesting and storage and it is similar to the recorded one for the seeds in the control variant**.**

Key words: cabbage, organic seed, seed yield/plant, seed weight, seed germination

Introduction

Organic seed producing is an important component for realizing of organic production (Lammerts van Bueren et al., 2003; Bonina and Cantliffe, 2004). In this aspect a special attention is taken into consideration about the production of organic seeds from vegetable crops especially from crossed pollinating biannual crops where should be applied different technological solution depending on the biological features and requirements of the crops (Paunero et al., 2003; Bonina and Cantliffe, 2004; Deleuran and Boelt, 2009).

Organic seeds from Bulgarian vegetable crops aren't still produced in Bulgaria as for the purpose of organic production could be used only organic seed from foreign varieties. The research investigations for realization of organic seed production in our country are in their first steps. There are still no enough studies concerning the evaluating of the sowing and economic properties of the organically produced seeds as such results are reported in garden pea only (Kalapchieva et al., 2011). The necessity of such kind of investigation is especially significant for cabbage where the basic difficulties are connected with the two years cycle of growing, the necessity of space isolation and pollination by insects. Bulgarian varieties suitable for growing in the conditions of organic productions are fixed in head cabbage being one of the main structure determining crops for our country (Antonova et al., 2007) but there are no any investigations performed on the economic and qualitative

characteristics of the seeds produced in organic conditions.
The aim of this study was to establish some of the seed yield and quality characterizations in head cabbage open pollinated variety Balkan produced in conditions of organic attempt.

Material and Methods

The experiment was performed with head cabbage open pollinated variety Balkan in conditions of organic and conventional attempt with two years cycle of plant growing at the Maritsa Vegetable Crops Research Institute, Plovdiv during the period 2006-2008.

Organic experiment: In the first year the plants were grown in conditions of organic production at open field (sowing – June; transplanting – July). Chosen plants typical for the variety were planted after reaching the economic maturity (October-November) in individual pots (15 l volume) with 10 l soil (from an area certified for organic production) and preliminary enriched with biohumus 200 ml/10 l soil (biohumus - biological fertilizer produced by Lumbricus rubelis and permitted for use in the organic production in Bulgaria). In autumn-winter period (October-February) the growing was realized under unheated greenhouses. In the beginning of entering in generative phase (March-April) the pods with chosen plants were fertilized with biohumus 100 ml/10 l soil and were moved in insect-protected isolated facilities installed in open field. Ten plants were grown in each isolator as the pollination in the isolator has been made by bees from stationary located nucleus (1 nucleus per isolator). Insect protected covers and nucleuses were removed after formation of the sets (in the beginning of May) and the plants were grown in open field conditions.

Control-conventional experiment: Plants grown in open (sowing – June and transplanting - July) by the technology for conventional late field production were used for the experiment. Chosen plants typical for the variety after reaching of economic ripeness (October-November) were planted in pods (15 l volume) with 10 l soil (from area used for conventional production) preliminary enriched with mineral fertilizers (16 g triple superphosphate and 13 g potassium sulphate for 10 l soil). Plants were fertilized and with 10 g ammonium nitrate before their moving in the isolated facilities. Growing in the cultivation facilities and the reproduction of the plants with conventional origin under isolators was made in terms and conditions that were identical to those applied for plants with organic origin.

The fertilization on the plants in the conventional and organic experiment was done according to recommendation after agrochemical analysis of the soil.

Plant protection bioproducts permit for organic production were applied in the organic variant during the generative-reproductive period while in the control – pesticides with chemical origin standard for conventional production were used for plant protection.

The experiment was conducted in 2 variants with 4 replications (10 plants/ isolator/ replication) as the isolator sizes were: weight 3m /length 3m /height 3m.

The following characters were studied: average seed yield/plant (g), absolute seed weight - weight of 1000 seeds (g) and seed germination (%)recorded in the year of harvesting (2006, 2007 и 2008) and after two year storage (2008, 2009 and 2010, respectively) in ordinary conditions without fumigation and disinfection of the seeds. In order the seed reproductivity to be read the plants were harvested individually in reaching of partial botanic ripeness of the pods followed by 14 day post-harvesting ripening at ordinary, non-controlled conditions. The absolute seeds weight was analyzed with samples, containing 1000 seeds in 4 replications as 100 seeds from 10 plants of each replication were taken randomly. The seeds germination was read averagely from 4 samples (100 seeds/sample), taken randomly – by 10 seeds from 10 plants of each replication. The reading was done 7 days after date of sample set.

The results obtained were processed mathematically and by analyze of variance (Lakin, 1990).

Results and Discussion

Different value of the studied characters depending on the test variants were registered in this study (Table 1).

The individual seed productivity of the plants from the organic experiment is 7.9 g/plant rather lower compared to that recorded for the control variant. The organic seeds are with smaller absolute weight 3,50 g than the seeds from the control variant but the average germination ability determined in the harvesting years of the seeds is high 94,15 % and it is almost identical to that registered in the conventionally produced seeds. The results concerning the germination of the organic seeds after 2 years of storage are of interest. The values recorded by this character 82 % are close to those for the stored seeds that have been produced conventionally.

According to the results from the analysis of variance (Table 2) the main factors of variability are a source of variation for the characters individual seed productivity, absolute weight and germination ability only that were recorded in the year of seed harvesting. The proven differences between the variants of the experiment have a dominant effect from 48.60 to 89.52 % on the varying of these characters (Table 3).

The analysis of the obtained results demonstrates that in the conditions of organic production in isolated facilities the individual seed productivity of the organically produced plants is low. The obtained organic seeds are with lower absolute weight but with high germination ability that is similar to the recorded one for conventionally produced seeds both after harvesting and after storage.

These results confirm those obtained by other researches in a great degree. Lower seed yield was established in pepper organic production but the organic seed germination activity is similar to those in conventionally obtained seeds (Duman, 2009). In study of garden pea in organic production schemes (Kalapchieva et al., 2011) was established that the obtained organic seeds are with lower absolute weight but high germination ability similar to the one established in seeds obtained by conventional production technology. However these results are obtained in open field conditions while the conditions in the study with head cabbage are specific and they are determined by the reproduction in isolated facilities. Probably a change in some parameters of the studied characters is possible to be expected in the open field conditions. Although the relative specificity of the obtained results they could be considered as an alternative for realization of organic seed production in head cabbage and to be used for development of technological decisions or technologies for organic seed production in this crop.

Conclusion

Individual seed productivity in organic experiment at head cabbage reproducing in isolated facilities is lower 7.90 g/plant compared to the recorded in the control.

Organic seeds that were obtained are with lower absolute weight 3.50 g but after harvesting and storage the germination ability of the organic seeds is high and it is similar to the recorded for the seeds in the control.

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Table 1. Characterization of the reproductivity and seed quality

Treatments	Average yield seeds/plant	Absolute seed weight	Seed germination[1]	Seed germination after storage
	(g)	(g)	%	%
	x±sd	x±sd	x±sd	
Control	11,25±0,55	4,31±0,45	94,75±5,00	83,25±4,25
Organic experiment	7,90±0,67	3,50±0,40	94,15±7,12	82,00±3,00
Average	9,58	3,91	94,45	82,63

x – mean ; sd – standard deviation; [1] – in the years of seed harvesting

Table 2. Analysis of variance of the reproductivity and seed quality

Sources of variation	df	Variance			
		Average yield seeds/plant	Absolute seed weight	Seed germination[1]	Seed germination after storage
Treatments	1	138,57***	18,18***	17,94***	5,26 ns
Years	2	2,79**	0,32*	3,92**	1,51 ns
Treatments x Years	2	2,32*	0,31*	1,74*	0,36 ns
Residual	18	0,332	0,086	0,426	1,194

*, ** ,*** - significance at p≤0.05, p≤0.01, p≤0.001; ns – non significant; [1] – in the years of seed harvesting

Table 3. Power of influence of variation factors on the reproductivity and seed quality

Sources of variation	Average yield seeds/plant	Absolute seed weight	Seed germination[1]	Seed germination after storage
	%	%	%	%
Treatments	89,52	88,94	48,60	-
Years	3,61	3,12	21,24	-
Treatments x Years	3,01	3,10	9,40	-

[1] – in the years of seed harvesting

Potential of autumn-sown rapeseed (*Brassica napus*) as a green manure crop

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Introduction

Rapeseed (*Brassica napus* L. var. *napus*) is an important oil crop in Serbia and many other European temperate regions (Marjanović-Jeromela *et al.*, 2011), with late summer- or early autumn-sown genotypes dominating over spring-sown ones. It is also a forage crop with a considerable potential for forage production due to high and stable forage yields, high crude protein content in forage dry matter and a prominent earliness (Marjanović-Jeromela *et al.*, 2010). In such way, rapeseed represents a multi-purpose crop for diverse farming systems.

Along with its main purpose, the autumn-sown cultivars of rapeseed kale may be successfully used for green manure and thus represent a valuable cover crop and a desirable member in forage crop rotations in organic farming and sustainable agriculture.

The aim of this study was to examine the potential of the autumn-sown rapeseed cultivars for the use as green manure crop.

Materials and Methods

A small-plot trial has been carried out in the trial years 2008/09 and 2009/10 at the Experimental Field of the Institute of Field and Vegetable Crops at Rimski Šančevi. It included ten autumn-sown rapeseed genotypes of Serbian origin, namely cultivars Banaćanka, Branka, Kata, Nena and Slavica and lines WOR 01, WOR 02, WOR 03, WOR 04 and WOR 05.

All ten genotypes were sown in early September, at a seeding rate of 50 viable seeds m^{-2}, and were cut in the stages of full budding and beginning of flowering (Krstić *et al.*, 2010).

There were monitored fresh aboveground biomass yield (t ha^{-1}), dry aboveground biomass yield (t ha^{-1}) and aboveground biomass nitrogen yield (kg ha^{-1}).

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

Results and Discussion

There were significant differences at both levels of 0.05 and 0.01 in all three monitored parameters of autumn-sown rapeseed potential for green manure production (Table 1).

The average fresh aboveground biomass yield ranged between 42.4 t ha^{-1} in the cultivar Kata and 77.1 t ha^{-1} in the line WOR 03. The line WOR 03 also had the highest dry aboveground biomass yield (6.9 t ha^{-1}), while the cultivar Kata and the line WOR 01 had the lowest dry aboveground biomass yield (3.8 t ha^{-1} both). These results confirm that certain genotypes of autumn-sown rapeseed have a great potential for aboveground biomass production (Mihailović *et al.*, 2008).

The average aboveground biomass nitrogen yield varied from 106 kg ha^{-1} in the cultivar Kata and the line WOR 01 to 193 kg ha^{-1} in the line WOR 03, somewhat lower than in fodder kale (Ćupina *et al.*, 2010).

Conclusions

Autumn-sown rapeseed has a considerable potential for green manure production due to high aboveground biomass nitrogen yields that regularly surpass 100 kg ha^{-1}, anticipating the possibility of the development of green manure specific rapeseed cultivars.

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Table 1. Average values of fresh above ground biomass yield, dry above ground biomass yield and above ground biomass nitrogen yield in autumn-sown rapeseed genotypes for 2008/09 and 2009/10 at Rimski Šančevi

Genotype	Fresh aboveground biomass yield ($t\ ha^{-1}$)	Dry aboveground biomass yield ($t\ ha^{-1}$)	Aboveground biomass nitrogen yield ($kg\ ha^{-1}$)
Banaćanka	66.6	6.0	167
Branka	48.2	4.3	121
Kata	42.4	3.8	106
Nena	66.8	6.0	167
Slavica	58.4	5.3	146
WOR 01	42.3	3.8	106
WOR 02	46.3	4.2	116
WOR 03	77.1	6.9	193
WOR 04	73.3	6.6	184
WOR 05	43.4	3.9	109
Average	56.5	5.1	142
$LSD_{0.05}$	5.6	1.1	38
$LSD_{0.01}$	8.2	1.5	55

Potential of spring-sown rapeseed (*Brassica napus*) as a green manure crop

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Introduction

Rapeseed (*Brassica napus* L. var. *napus*) is one of the most significant oil crops in many European temperate regions such as Serbia (Marjanović-Jeromela *et al.*, 2011). In such climates, late summer- or early autumn-sown genotypes usually dominate over spring-sown ones. The spring-sown genotypes of rapeseed are also suitable for forage production due to moderately high and stable forage yields, high crude protein content in forage dry matter and a distinctive earliness (Mikić *et al.*, 2010), representing a multi-purpose crop for diverse farming systems.

Apart from its main purpose, the spring-sown cultivars of rapeseed kale may be successfully used for green manure, thus representing a valuable cover crop and a regular member in various forage crop rotations in contemporary trends such as organic farming and sustainable agriculture.

The goal of this study was to assess the potential of the spring-sown rapeseed cultivars for the specific use as a green manure crop.

Materials and Methods

A small-plot trial has been carried out in the trial years 2008/09 and 2009/10 at the Experimental Field of the Institute of Field and Vegetable Crops at Rimski Šančevi. It included ten autumn-sown rapeseed genotypes, namely six cultivars, Canada, Galant, Global, Jasna, Liaison and Lisora, and four lines, SOR 01, SOR 02, SOR 03 and SOR 04.

All ten genotypes were sown in early March, at a seeding rate of 50 viable seeds m^{-2}, and were cut in the stages of full budding and beginning of flowering (Ćupina *et al.*, 2010).

Fresh aboveground biomass yield (t ha^{-1}), dry aboveground biomass yield (t ha^{-1}) and aboveground biomass nitrogen yield (kg ha^{-1}) were monitored.

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

Results and Discussion

There were significant differences at both levels of 0.05 and 0.01 in all three monitored agronomic characteristics of spring-sown rapeseed potential for green manure production (Table 1).

The average fresh aboveground biomass yield ranged between 23.6 t ha^{-1} in the line SOR 04 and 54.8 t ha^{-1} in the cultivar Jasna. The cultivar Jasna also had the highest dry aboveground biomass yield (4.9 t ha^{-1}), while the line SOR 04 had the lowest dry aboveground biomass yield (2.1 t ha^{-1}). These results confirm that certain genotypes of spring-sown rapeseed have a potential for aboveground biomass production, while generally lower than those in autumn-sown fodder kale or autumn-sown rapeseed.

The average aboveground biomass nitrogen yield varied from 57 kg ha^{-1} in the line SOR 04 to 132 kg ha^{-1} in the cultivar Jasna, non-significantly lower than in spring-sown white mustard (Krstić *et al.*, 2010).

Conclusions

It may be regarded that the spring-sown genotypes of rapeseed have a satisfying potential for green manure production, as well as the aboveground biomass nitrogen yields that regularly surpass 50 kg ha^{-1}, being a solid basis for the development of green manure specific rapeseed cultivars with enhanced earliness.

Acknowledgements

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Table 1. Average values of fresh above ground biomass yield, dry above ground biomass yield and above ground biomass nitrogen yield in spring-sown rapeseed genotypes for 2008/09 and 2009/10 at Rimski Šančevi

Genotype	Fresh aboveground biomass yield (t ha^{-1})	Dry aboveground biomass yield (t ha^{-1})	Aboveground biomass nitrogen yield (kg ha^{-1})
Canada	25.4	2.3	61
Galant	33.1	3.0	79
Global	35.0	3.2	84
Jasna	54.8	4.9	132
Liaison	37.1	3.3	89
Lisora	38.4	3.5	92
SOR 01	26.4	2.4	63
SOR 02	32.4	2.9	78
SOR 03	25.0	2.2	60
SOR 04	23.6	2.1	57
Average	33.1	3.0	80
$LSD_{0.05}$	5.6	1.1	38
$LSD_{0.01}$	8.2	1.5	55

Assessing the impacts of increased temperature on mustard (*Brassica juncea* L.) yields using real time data from diverse environments

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Abstract

Climate change projections for two widely spaced regions of India (Jammu and Assam) in 2030's indicate that temperature increase would be similar but rainfall departures are going to differ substantially. Mustard yields under rainfed conditions were found to be influenced by temperature in the early vegetative growth favourably and as seasonal temperatures are increasing yields are decreasing. Response to a rise in minimum temperature is not uniform across locations with the crop responding positively in a cool, dry climate and conversely in a warm and humid climate. Response of the crop to increased temperatures in future climates from generated weather variables indicated that crop yields are likely to decrease by 14.3% and 19.4% in Jorhat; 9.25% and 18.6% in Rakh Dhiansar if the seasonal maximum temperature rises by 1 and 2 °C, respectively. The response to rise in minimum temperature is not uniform at both the locations. With increase in seasonal rainfall during vegetative stage at Jorhat and during reproductive stage at Rakh Dhiansar, the yields were found to decrease.

Introduction

India is a major mustard /rapeseed growing country standing first in terms of area and second in terms of total production in the world. However, a potential yield gap 860 kg ha^{-1} exists for Indian conditions (Aggarwal, 2008). Climate change projections for Himalayan region indicate a temperature rise of 1.7 to 2.2°C in 2030's compared to 1970's. For north-eastern region, the projections are in the range of 1.8 to 2.1°C. The PRECIS run for 2030's indicates that the annual rainfall in the Himalayan region is likely to increase by 60 to 206 mm, whilst in the north-eastern region the annual rainfall is projected to increase marginally with a substantial decrease during the winter months of January and February (INCCA, 2010). In the light of these projections on the future climatic scenarios, an assessment is made on the likely effect of the changes in these weather parameters on mustard yields grown under rainfed conditions in India. To accomplish this, long term mustard yield data of c.v. Varuna from two diverse environments viz., Himalayan (Rakh Dhiansar) and north-eastern (Jorhat) region of India were utilized. Rakh Dhiansar (32°43'N; 74°52'E; 332m AMSL) experiences dry sub-humid climate with dry winters. The average annual rainfall is 1108 ± 272mm with a variability of 24%. Mustard is grown on alluvial soils during 2nd fortnight of October to 1st fortnight of March during which the normal rainfall is 50.4 mm with a variability of 85%. The crop duration is generally 140 days with an average yield of 647 kg ha^{-1}. Jorhat (26°45''N; 94°13'E; 86.6m AMSL) experiences mostly humid climate with an annual rainfall of 1868 ± 267mm with a variability of about 14 %. The crop is generally sown around 2nd fortnight of October but matures in 105 to 110 days with an average yield of 1200 kg ha^{-1}.

Materials and Methods

Mustard yield data from field experiments conducted during *rabi* seasons under the aegis of All India Coordinated Research Project on Agrometeorology under rainfed conditions were collected for the period 1996-97 to 2006-07 (except for 2001-02) at Rakh Dhiansar and for 1997-98 to 2004-05 at Jorhat. The crop was uniformly fertilized with 40-40-20 kg N, P_2O_5 and K_2O ha^{-1}. Necessary plant protection measures were taken to keep the crop free from pests and diseases at both the locations. The soil of test site was alluvial at Rakh Dhiansar and fine loamy at Jorhat. The corresponding meteorological data were collected from nearby observatories at the both locations and the data were arranged into weekly means. A crop season of 15 weeks was considered for Jorhat and 20 weeks for Rakh Dhiansar to quantify the effect of weather variables. Correlation and regression studies were carried out to identify the most critical weather variable. Individual effects of weather parameters on crop yields were studied by Jain *et.al.* (1980) and yield forecast models based on weather factors were constructed by Agrawal *et al*. (1986). A modified statistical model of Jain *et.al.,* (1980) was employed in present study, considering effects of changes in weather parameter on yield in a given week as a linear function of respective correlation coefficient between yield and weather variable. The trend influence considered by Jain *et.al.* (1980) was not considered in the present study as the cultivar and management practices were similar in all the years and yield variations are due to weather influence only.

$$\mathbf{Y = a + b_0 \sum_{w=1}^{n} X_w + b_1 \sum_{w=1}^{n} r_{xy(w)}\ X_w + \ b_2 \sum_{w=1}^{n} r^2{}_{xy(w)} X_w = a + b_0 Z_0 + b_1 Z_1 + b_2 Z_2}$$

Where, Y is mustard yield (kg ha^{-1}); a, b and c are constants; n is number of weeks up to the time of harvest; w is week identification; X_w is the value of weather variable under study in w^{th} week; $r_{xy(w)}$ is correlation coefficient between yield and weather variable in w^{th} week; Z is generated weather variable. The above model was employed to assess the impact of climatic change in terms of increased temperature alone on mustard yield by increasing mean seasonal temperatures by 1, 2 and 3°C in the generated weather variables.

Results and discussion

At Rakh Dhiansar, the crop experienced low temperatures in the range of 9.8 -10.2°C during early vegetative phase and in the range of 7.2 to 7.5°C during reproductive stages. The temperatures were on some days as low as 0.2°C. Contrary to this, the crop experienced relatively warmer crop seasons at Jorhat as the mean seasonal minimum temperature during early vegetative phase and during flowering and siliqua formation stages being 13.2 to 13.7°C and 10.0 to 10.2°C, respectively. Initially weekly mean values of all the weather variables were correlated with yield which showed that maximum, mean and minimum temperatures along with rainfall significantly influenced the yield at both the locations for most part of the crop season. There were some weeks where the relative humidity had some influence but the effect was not consistent all through the crop season and hence ignored. The crop responded favourably to minimum temperature at Rakh Dhiansar as the prevailing temperatures were lower than the critical values for growth during vegetative stage. The correlation coefficients between different weather variables and yield indicated significant negative correlations with maximum and minimum temperature at both the locations in the early vegetative stage but at Rakh Dhiansar the association changed its direction at reproductive stage. Linear regression studies resulted in significant coefficient of determination (R^2) values for minimum temperature at Jorhat alone and with the maximum temperature, R^2 values were not significant (Fig 1).

Climatic change assessment: The influence of climatic change assessment is made by incorporating increased temperatures in the generated weather variables by 1, 2 and 3°C in the above model. The analysis resulted in significant R^2 values for all the weather variables considered and indicated that that crop yields are likely to decrease by 14.3, 19.4 and 29.1% in Jorhat and 9.3, 18.6 and 28.0% in Rakh Dhiansar if the seasonal maximum temperature rises by 1, 2 and 3°C, respectively. The magnitude of response to a rise in minimum temperature is not uniform at both the locations. At Jorhat the yield decrements were 11.8, 23.6 and 35.5% for 1, 2 and 3°C rise and at Rakh Dhiansar the yield decrements were 2.4, 4.8 and 7.2% only for the same rise in minimum temperatures. An increase in rainfall during reproductive stage (>65 mm) was found to drastically reduce the yields at Rakh Dhiansar and at Jorhat excess rainfall (>40 mm) during vegetative stage was found to be detrimental.

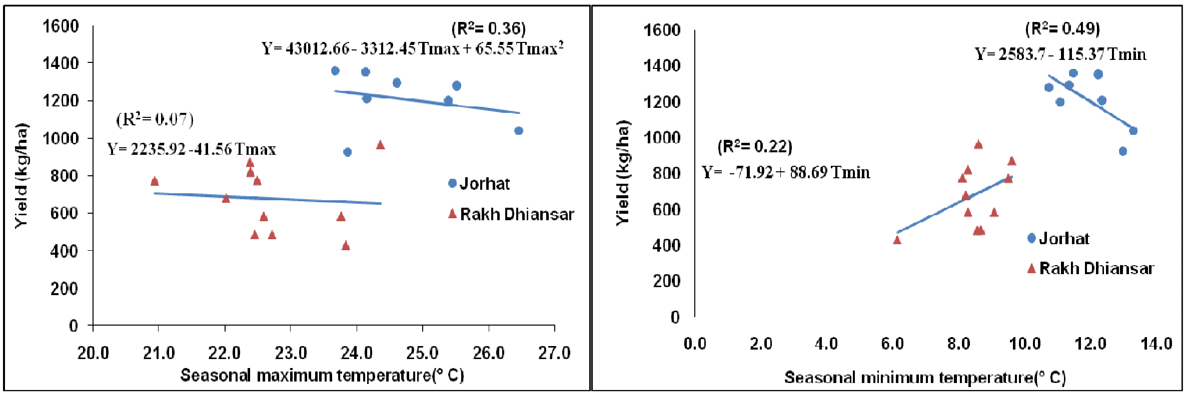

Fig. 1. Influence of temperature on mustard yields at two divergent locations

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Transpiration responses to vapor pressure deficit in mustard (*Brassica juncea* L)

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Introduction

In plant water system, loss of water vapour through plant leaf stomata known as transpiration is governed by the pressure, ambient temperature, humidity *etc*. The transpiration stream moving through the xylem vessels from roots to shoots is mainly driven by vapour pressure deficit i.e. leaf to air vapour pressure difference. Vapour pressure deficit (VPD) is difference between the amount of moisture in air and how much moisture the air can hold in the saturated condition. Higher VPD means that the air has higher capacity to hold the water to stimulate water vapour transfer into atmosphere i.e. transpiration. Thus the rate of transpiration is determined by the steepness of vapour pressure deficit gradient and increase in ambient temperature. Sinclair and Bennett (1998) reported that atmospheric evaporative demand, and consequently crop transpiration increase with increasing atmospheric vapor pressure deficit (VPD). However, the transpiration response to VPD differs with crops (Turner et al., 1984) and within species (Isoda and Wang, 2002). Mustard is an important crop in the subtropical region of Jammu, mainly grown under rainfed condition where water deficits commonly develop in the early part of the season due to low humidity (high VPD) environments. In these environments, restricted transpiration rate during the middle of the day with high vapor pressure deficit would result in water conservation allowing for both increased yield and water use efficiency. In this paper the relationship is presented between transpiration and vapour pressure deficit under field condition.

Materials and Methods

Field experiments were conducted during *rabi* seasons 2003-04,2004-05 and 2005-06 at research farm of Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu (32′ 40^0 N, 74′ 58 ^{0} E and 332 m.a.s.l) having sandy loam soil with medium water holding capacity and poor in nitrogen, phosphorous and potash. The treatments included three dates of sowing: 10^{th} October (D_1), 25^{st} October (D_2) and 5^{th} November (D_3) and two mustard varieties Pusa bahar($V_{1)}$ and Varuna ($V_{2)}$ under rainfed and irrigated conditions, respectively with four replications. Periodically Canopy-air temperature differences were recorded in mustard crop in all the treatments at different stages with the help of Infrared thermometer (Teletemp, Model, AG-42) in order to know plant water status. The recordings of canopy-air temperatures differences were made on clear day at 13.00 hours IST in order to minimize the sun angle effect and when the heat load is maximum. The emissivity of Infrared Thermometer was kept at 0.99. Simultaneously, the transpiration data were also recorded with the help of Study State Porometer (Model LI-1600)

The VPD was calculated as difference between saturation vapour pressure and actual vapour pressure at canopy temperature and ambient temperature recorded with the help of Infrared Thermometer as reported by Prenger & Ling (2001).

$VPD = e_s - e_a$

e_s = Saturation vapour pressure at the canopy temperature

e_a = Actual vapour pressure at ambient temperature

$$e_s = \frac{0.6108 \exp (17.27 \times Tc)}{(Tc+237.3)}$$

$e_a = e^0 (Ta) \times RH/100$

$$e^0 (Ta) = \frac{0.6108 \exp (17.27 \times Ta)}{(Ta+237.3)}$$

Tc = Canopy temperature Ta = Air/ Ambient temperature

Results and discussion

In order to quantify the response of transpiration to the vapour pressure deficit at field level, the values of the transpiration rate recorded periodically were correlated with VPD estimated from canopy and air temperature of the corresponding day of observation for all the treatments pooled over the r*abi* seasons 2003-04 , 2004-05 and 2005-06. The correlation coefficient obtained was highly significant (r = 0.82). The above periodical data of VPD and transpiration rate were subjected to regression analysis and the linear relationship was found indicating that transpiration rate increases with increase in vapour pressure deficit. Similar explanation was given bygiven by Sinclair and Bennett (1998).The model so obtained from the relationship is as under:

$$\mathbf{Y = 0.19\ (VPD) + 0.13 \qquad R^2 = 68\ \%}$$

The R^2 indicates that VPD accounts 68 per cent in the transpiration rate and relationship so obtained is depicted in Fig 1.

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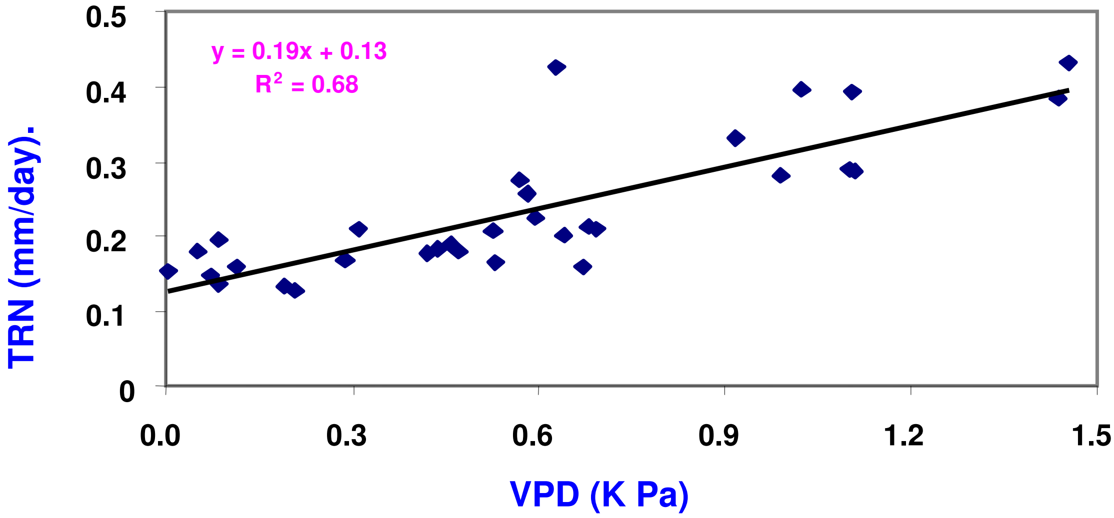

Fig.1 Relationship between transpiration (TRN) and Vapour pressure Deficit (VPD) in mustard crop

Evaluation of head cabbage genotypes in the aspect of their use as initial material for organic breeding

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Abstract

In the period of 2008 – 2010 two Bulgarian varieties Besapara and Maritsa 48/5 and 2 breeding lines A – 38 and K - 38 -05 of white head cabbage, grown in two systems for organic production and control – standard conventional production system, were studied in the Maritsa Vegetable Crops Research Institute – Plovdiv. The purpose of the study was to evaluate the potential of the head cabbage genotypes as an initial material for organic breeding.

It was established that varieties Besapara and Maritsa 48/5 as donors of good potential for productivity in the conditions of organic production and lines A – 38 and K - 38 -05 as sources of slight susceptibility to the studied complex of diseases and pests could be used as initial material for organic breeding. Desired combination of good productivity and slight susceptibility to the whole complex of the studied factors of biotic stress has been not observed in the studied head cabbage genotypes.

Key words: head cabbage, organic breeding, productivity, disease, pests

Introduction

Plant organic breeding is a new modern direction in the research programmes orientated to development of organic varieties supporting the realization of the sustainable organic production (Lammerts van Bueren, 2002; Murphy et al., 2007; Lammerts van Bueren, 2008; Lammerts van Bueren et al., 2010). The investigations concerning the plant organic breeding are few in Bulgaria. The organic breeding in vegetable crops is still unfamiliar in our country although particular components of it concerning mainly the resistance and tolerance to some of factors of the biotic and abiotic stress have been developed in most research programmes. Preliminary estimations of genetic resources (varieties, lines, accessions and populations) in vegetable crops about their use in the conditions of organic production have not yet carried out in our country (except for the investigations in garden pea performed by Kalapchieva et al., 2011) while in other countries such investigations are already conducted (Varghese, 2000; Miles, 2004; Chable et al., 2008; Zdravkovic et al., 2010). Therefore it is necessary to start an organic breeding orientated at the beginning to identification of initial material with various biological potential for realization in the organic production conditions.

The purpose of the study was to be evaluated the potential of the head cabbage genotypes as an initial material for organic breeding.

Material and Methods

In the period of 2008 – 2010 two Bulgarian varieties Besapara and Maritsa 48/5 and 2 breeding lines A – 38 and K - 38 -05 of white head cabbage, grown in two systems for organic production and control – standard conventional production system, were studied in the Maritsa Vegetable Crops Research Institute – Plovdiv. (The studied genotypes are created without applying of biotechnological methods, induced mutagenesis or methods for genetic modifying of the organisms). Plant genotypes were cultivated by the late field production technology with sowing date 17 – 20 of June by standard seeds that were conventionally produced and transplanting – 25 – 30 of July on high flat bed. The experiments were set by block method in 4 genotypes, 3 systems, in 4 replications (22 plants/ replication) by 90+70/60 cm scheme. The studying was done in the following systems: control – conventional production system with use of standard mineral fertilization N20P15K12 kg/da and plant protection based on insecticides with chemical origin; organic system I – growing without fertilizer and insecticide treatment of the plants. ; organic system II – growing by use of biological fertilizer* – biohumus (produced by Lumbricus rubelis) in rate of 300 L/da (advisable after agrochemical analysis of the soil) and plant protection with biological insecticides (BioNeem plus 1,5 EC 0,25 %, Neem Azal T/S 0,3 %, Pyrethrum 0.05%, Pyros 0.08%) and biofungicides (Timorex 66 EC 1%) which are permitted for use in the organic production in Bulgaria. The trials with organic systems were set on an area free of fertilization and pesticide treatment in the period 2002 – 2008 according to the principles for organic production.

The following characters were studied in the experimental period: total plant biomass (kg); cabbage weight (kg); degree of infestation of the economic ripening stage as index of attack (%) calculated by McKinney to: downy mildew *Peronospora parasitica* (by adapted scales modified by Leckie et al., 1996), alternaria blight *Alternaria brassiciola* (by adapted scales modified by Conn et al.,1990), cabbage aphid *Brevicoryne brassicae* (by adapted scales modified by Ellis et al.,1998), and lepidoptherans - cabbage butterfly *Pieris brassicae,* turnip white butterfly *Pieris rapae* and cabbage moth *Mamestra brassicae* (by adapted scales modified by Dickson and Eckenrode, 1980). In the three years of the study bacterial blight *Xanthomonas campestris pv.campestris* was not observed. The total biomass and cabbage weight was examined by analyzing of 10 plants from each replication while the infestation of pests was read as the measurements were done for all plants from each replication of the each genotype in the period October – November.

Data obtained were mathematically processed by analysis of variance (Lakin, 1990).

Results and Discussion

It was established that the genotypes studied in this investigation demonstrate different biological potential shown depending on both the genetic features of the studied head cabbage varieties and lines and of the differences in the production systems (Table 1). In organic system I cultivation the values of the head cabbage weight are lower in all genotypes compare to the control. Great differences between the genotype were observed in organic system II. The head cabbage weight of the Bulgarian varieties Besapara and Maritsa 48/5 was surprising greater in this growing variant compared to the control while the cabbage weight of the lines A – 38 and K - 38 -05 was too lower. The differences that were observed retain the same regarding the total plant biomass. Differences were also recorded regarding the degree of disease and pest infestation as awaited the values are the lowest in conventional production (Table 1). Differences are the greatest in infestation from leaf caterpillars as in the organic systems the indexes vary from 24.80 % to 72.00 %. Compared to the studied varieties lines A – 38 and K - 38 – 05 are described with lower attack of this pest. It is observed a comparatively low variation between the three variants of treatment in each one of the studied genotypes regarding the susceptibility to the remaining pests and the pathogens-agents of diseases.

The observed diversity in the expression of the studied characters depends on the influence that the main factors of variability exert: the proven genetic diversity between the studied genotypes, differences between the

three production systems and years of study and specific interactions between these factors of variation (Table 2).
The comparative analysis of the obtained results demonstrates the presence of strongly expressed differentiation between the studied genotypes that is determinated mainly in their potential for productivity and their response to the attack of leaf caterpillars. Varieties Besapara and Maritsa 48/5 could be used for organic breeding basically in the aspect of their better productivity in conditions of organic production. However in these conditions the varieties are susceptible to leaf caterpillars attack. Head cabbage lines A – 38 и К - 38 – 05 being with comparatively lower susceptibility to leaf caterpillars attack could be also used as a starting material for organic breeding but it should be taken into consideration the fact that these lines show too low productivity in the conditions of organic production. The desired combination of good productivity and low susceptibility to the whole complex from the studied factors of biotic stress was not observed in the studied varieties and lines.
These results could be considered and as an indication for existence of specific adaptability to organic crop production which the tested genotypes showed with some of studied characters. The presence of good productivity in the varieties and lower susceptibility in the lines in conditions different from those typical for the developed genotypes offer a good opportunity for an application of the genotypes as initial material for organic breeding.

Conclusion

The head cabbage varieties Besapara and Maritsa 48/5 could be used as initial material for organic breeding as donors of good potential for productivity in the conditions of organic production.
The lines A – 38 and К - 38 -05 could be used as initial material for organic breeding as sources of slight susceptibility to the studied complex of diseases and pests.
Desired combination of good productivity and slight susceptibility to the whole complex of the studied factors of biotic stress has been not observed in the studied genotypes

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Table 1. Characters of Bulgarian varieties and lines white head cabbage

Varieties/ lines	Systems*	Cabbage weight	Total plant biomass	Degree of infestation			
				P. parasitica	*Alt. brassicicola*	*B. brassicae*	*Lepidoptera*
		kg	kg	%	%	%	%
Maritsa48/5	1	**1,670**	**3,100**	**4,13**	**1,50**	**11,75**	**21,90**
	2	1,383	2,600	7,50	2,00	16,70	61,33
	3	1,820	3,340	5,00	1,75	14,00	57,40
Besapara	1	**1,331**	**3,010**	**4,75**	**1,00**	**12,00**	**18,33**
	2	1,028	2,795	6,38	1,50	16,31	72,00
	3	1,609	3,255	4,75	1,75	14,33	69,25
A - 38	1	**1,225**	**1,780**	**2,75**	**0,00**	**10,00**	**17,40**
	2	0,531	0,843	3,75	1,25	14,84	39,25
	3	0,685	1,182	3,75	1,25	13,66	26,73
K - 38 -05	1	**1,556**	**2,157**	**1,63**	**0,75**	**11,25**	**16,35**
	2	0,665	1,020	3,00	1,00	16,25	29,49
	3	0,778	1,230	2,75	1,00	11,34	24,80

Systems: 1 – control; 2 - organic system I; 3 - organic system II

Table 2. Three factorial analysis of variance

Sources of variation	Degree of freedom	Variance					
		Cabbage weight	Total plant biomass	*Peronospora parasitica*	*Alternaria brassicicola*	*Brevicoryne brassicae*	*Lepidoptera*
Genotypes (G)	3	5,54***	2,06***	103,00***	1,74***	43,71***	7288,06***
Systems (S)	2	4,17***	4,18***	80,55***	7,49***	305,13***	14690,18***
Years (Y)	2	0,04**	0,03 *	10,47***	24,23***	486,02***	387,17***
G x S	6	0,86***	0,62***	22,66***	0,99***	8,44***	1898,99***
G x Y	6	0,02 *	0,04***	1,71***	1,02***	10,14***	43,22***
S x Y	4	0,02*	0,04**	2,10***	1,19***	3,96*	62,64***
G x S x Y	12	0,05***	0,05***	2,06***	0,16***	7,93***	22,49***
Residual	108	0,008	0,009	0,24	0,04***	1,24	6,64

*,**,*** - proven in level of significance p≤0.05, p≤0.01, p≤0.001;

Achievements in rapeseed (*Brassica napus*) breeding in Serbia

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Introduction

Rapeseed (*Brassica napus* L.) has been receiving an increased attention in Serbia during past few decades, mostly because of its price, regularly higher in comparison to those of sunflower (*Helianthus annuus* L.) or soybean (*Glycine max* (L.) Merr.), as well as due to the production of bio-diesel, where rapeseed is considered the most quality crop for this purpose (Marinković *et al.*, 2007). It is estimated that the needs of the country for rapeseed could be answered by the cultivation area of about 60,000 ha.

Conventional Breeding

Today, the Institute of Field and Vegetable Crops in Novi Sad (IFVCNS) remains the only institution in Serbia dealing with rapeseed breeding, biotechnology, agronomy, seed production and other forms of research. The work on rapeseed at IFVCNS was radically intensified in 1984, with foreign cultivars as the basic material for breeding. Novel genetic variability was created by using the convergent hybridisation, according to the principle of transgressive recombination. So far, at IFVCNS there have been developed ten autumn-sown rapeseed cultivars (Banaćanka, Branka, Jasna, Kata, Nena, Nevena, NS Jelena, Slavica, Zlatna and Zorica) and two spring-sown rapeseed cultivars (Jovana and Mira) registered in Serbia (Marjanović-Jeromela *et al.*, 2006). The cultivar Anna was registered in the Ukraine and the cultivar Ilia in the European Union (Romania), while a certain number of other lines are in the process of official registration in other European countries.

Breeding strategies at IFVCNS related to rapeseed are based upon the basic research of seed yield components and seed yield and quality, with emphasis on oil and protein composition.

Breeding rapeseed for seed yield is aimed at optimising the relationship among individual seed yield characteristics, especially between number of husks per plant and seed yield per plant, as well as at harmonising the ecophysiological aspects, such as a short and intensive flowering period and a prolonged activity of the topmost leaves since their decisive impact on seed yield.

Breeding for increased tolerance to various forms of abiotic and biotic stress is targeting the low temperatures and winter hardiness and their impact on flowering time, as well as the major diseases, such as *Peronospora parasitica* (syn. *P. brassicae*), *Alternaria brassicae*, *Phoma lingam* and *Sclerotinia sclerotiorum*.

Among the seed quality parameters, the most important are oil content and oil composition, protein content, glucosinolate content and fibre content. In the rapeseed genotypes with dark-coloured seedcoat, it is possible to increase the oil content up to 5% and the protein content for 1% (Marjanović-Jeromela *et al.*, 2007). A specific stress is put on reducing the content of linoleic acid and increasing the content of oleic acid, as achieved in the cultivar Kata, with 72.3% of oleic acid.

The meal remaining after the oil extraction may contain up to 40% of crude protein and is used in animal feeding. Breeding rapeseed at IFVCNS for this purpose is directed towards developing the lines with a low content of glucosinolates and with light-coloured seedcoat, since it is positively correlated with the rapeseed meal quality.

Molecular Breeding and Cytogenetics

The conventional methods in rapeseed breeding are more and more accompanied by the use of various molecular tools. So far, the most prominent role in assisting the selection of the genotypes with desirable traits has been played by RAPD and SSR molecular markers. The application of SSR markers in rapeseed breeding programme at IFVCNS was rather successful in locating quantitative trait loci (QTL) for low temperature resistance, winter hardiness and flowering time. A broad analysis of the QTL controlling the oil acid composition collocated these with those being responsible for the oil quality.

The development of F_1 hybrids in rapeseed is based upon the *ogura* type of cytoplasmic male sterility (CMS). This CMS type was successfully introduced in numerous lines developed at IFVCNS, currently at the final stages of development into cultivars for wide use in Serbia and other countries. A detailed study of the CMS in rapeseed at IFVCNS comprised diverse material, such as the self-pollinating progenies of a hybrid genotype, sterile inbred lines, progenies of backcrosses between sterile plants and fertility restorers and different CMS types introduced into the Novi Sad breeding material and the restorer (Atlagić *et al.*, 2007). Major cytogenetic research is aimed at meiosis analysis and pollen vitality. The results so far have contributed to the detection of CMS, as well as to the success of restoring male fertility in breeding material.

Conclusions

Breeding rapeseed in Serbia has numerous achievements contributing to both local and European rapeseed research and production. It is also faced with many challenges, common to the other breeding programmes in Europe and worldwide. We may anticipate a much broader integration of the rapeseed breeding programmes in Serbia and other West Balkan Countries into the existing research carried out in the European Union to the common benefit.

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Green forage yield components in brown mustard (*Brassica juncea*)

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Introduction

Brown mustard (*Brassica juncea* (L.) Czern.) is one of the most important oil brassica species, especially in Indian subcontinent (Mahmood *et al.*, 2005). The fact that this species is characterised by numerous desirable agronomic characteristics, such as heat and drought tolerance or shattering resistance, was the reason for breeding the first canola (low erucic acid, low glucosinolate) brown mustard cultivars.

Breeding and growing brown mustard for forage production demands a study on its forage yield components and their mutual relationship resulting in the development of brown mustard cultivars with high and stable green forage yields.

The aim of this study was to assess the variability and the correlation of green forage yield components and green forage yield in brown mustard genotypes.

Materials and Methods

A small-plot trial has been carried out in 2009 and 2010 at the Experimental Field of the Institute of Field and Vegetable Crops at Rimski Šančevi. It included eight brown mustard genotypes of diverse geographic origin.

In both years, all eight genotypes were sown in early March, at a seeding rate of 50 viable seeds m^{-2}, with a plot size of 5 m^{2} and three replicates, and were cut in the stages of full budding and beginning of flowering (Mihailović *et al.*, 2008).

There were monitored plant height (cm), number of lateral branches (plant^{-1}), number of internodes (plant^{-1}), stem mass (g plant^{-1}), leaf mass (g plant^{-1}) and green forage yield (g plant^{-1}). The study results were processed by analysis of variance (ANOVA) with the Least Significant Difference (LSD) test applied. There were calculated simple correlation coefficients (r) between each of the monitored characteristics.

Results and Discussion

There were significant differences at both levels of 0.05 and 0.01 in forage yield components between the examined brown mustard genotypes (Table 1). The genotype BM 06 had the greatest average values for plant height (85 cm), number of lateral branches (5 plant^{-1}) and number of internodes (44 plant^{-1}). The average stem mass varied from 24.56 g plant^{-1} in BM 01 to 52.66 g plant^{-1} in BM 06, while the average leaf mass ranged between 29.88 g plant^{-1} in BM 02 and 61.22 g plant^{-1} in BM 04. The genotype BM 04 also had the highest average green forage yield (107.97 g plant^{-1}).

Majority of the forage yield components were significantly and positively correlated (Table 2). Green forage yield was highly and positively correlated to leaf mass (r = 0.952), as in fodder kale (Mihailović *et al.*, 2009), and stem mass (both r = 0.953), number of internodes (r = 0.807) and number of lateral branches (r = 0.869). Among the forage yield components it is number of lateral branches and number of internodes that were most positively correlated (r = 0.972).

Conclusions

Some of the tested brown mustard genotypes have high green forage yield per plant and a desirable relationship between green forage components, deserving attention by forage brassica breeders as parental lines in developing forage brown mustard cultivars.

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Table 1. Average values of green forage yield components and green forage yield in brown mustard genotypes for 2008 and 2009 at Rimski Šančevi

Genotype	Plant height (cm)	Number of lateral branches (plant^{-1})	Number of internodes (plant^{-1})	Stem mass (g plant^{-1})	Leaf mass (g plant^{-1})	Green forage yield (g plant^{-1})
BM 01	68	2	17	24.56	35.66	133.16
BM 02	77	3	23	33.44	29.88	46.47
BM 03	56	3	21	30.29	43.23	34.79
BM 04	74	4	29	46.75	61.22	133.69
BM 05	81	2	16	26.77	33.25	116.70
BM 06	85	5	44	52.66	48.58	34.57
BM 07	75	3	24	26.88	34.51	42.52
BM 08	68	4	33	49.88	55.42	154.16
$LSD_{0.05}$	15	2	7	5.34	3.98	9.32
$LSD_{0.01}$	19	3	19	7.79	6.18	13.97

Table 2. Simple correlation coefficients (*r*) between green forage yield components and forage yield in brown mustard genotypes

* significant at 0.05 ** significant at 0.01	Number of lateral branches	Number of internodes	Stem mass	Leaf mass	Green forage yield
Plant height	0.260	0.373	0.267	-0.127	0.074
Number of lateral branches		0.972**	0.935**	0.720*	0.869**
Number of internodes			0.912**	0.623	0.807*
Stem mass				0.814*	0.953**
Leaf mass					0.952**

Genetic variability and correlation studies on germplasm of yellow sarson (*B. rapa* L. var. yellow sarson) for seed yield and its component traits

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Abstract
Genetic variability and correlation in sixty nine indigenously collected germplasm accessions of yellow sarson were evaluated for seed yield and its components traits. Analysis of variance for seed yield and its related components showed that there was significant variability among the accessions. The maximum PCV was observed in seed yield per plant followed by seeds per siliqua. High heritability coupled with high genetic advance was observed for plant height, seeds per siliqua, 1000-seed weight, seed yield per plant and harvest index. The seed yield per plant was positively and significantly correlated with main shoot length, siliquae on main shoot, primary branches per plant, oil content, 1000-seed weight, harvest index and days to maturity. The accessions IC 361512, IC 342762 and IC 334290 were identified as useful genotypes for various traits.

Introduction
Rapeseed-mustard is an important group of crop plants with great economic value world wide. *Brassica juncea* (Indian mustard) and *B. rapa* are the important oilseed crops in India. The *B. rapa* is divided into three ecotypes viz., toria, brown sarson and yellow sarson, which are grown in India. Of these three ecotypes, yellow sarson is self compatible in breeding behavior and is one of the most important members among them. Yellow sarson is mainly grown in Assam, Bihar, Uttar Pradesh, Sikkim and West Bengal (Misra, 2008). It occupies an important position due to the presence of high oil content (up to 45 %), high seed yield and early maturity (around 100 days) as compared to Indian mustard (130-150 days), furthermore, it's yellow seed coat colour has preference over brown seed colour. The oil is mainly used for edible purposes and in addition to this, the yellow sarson is most preferred choice as leafy vegetables among the entire cultivated oilseed Brassicas in India (Chatterjee, 1992).

The improvement for yield and other traits not only depend on the amount of variability present in the breeding materials for the required traits but also on proper evaluation and further, their utilization in the breeding programmes (Kumar *et al.,* 2004; Kumar and Misra, 2007). The present study was under taken to find out variability for 15 agro-morphological traits in the yellow sarson germplasm. The estimation of extent and nature of variability in the germplasm accessions for yield and other economic traits is the pre-requisite for breeding programme. The effectiveness of selection for seed yield depends upon both, the genetic variability present in the population and the degree of association that exist between seed yield and its components traits. Therefore, the present investigation is undertaken to estimate the magnitude of genetic variability and correlation in the diverse germplasm of yellow sarson and for selection of superior/ promising genotypes.

Materials and Methods

Sixty nine accessions of yellow sarson (*Brassica rapa* L. var. *yellow sarson*) were evaluated during *rabi* season 2008-09 in an augmented complete block design with four checks (NDYS 2, Pusa gold, Ragani and YST 151) at the Directorate of Rapeseed–Mustard Research, Bharatpur, Rajasthan (India). Theses indigenously collected accessions of yellow sarson were acquired from National Bureau of Plant Genetic Resources, New Delhi (India). Each genotype was sown in paired rows of 3m length with 30 x 10 cm spacing. Recommended standard agronomic package of practices and plants protection measures were adopted. Randomly tagged five plants were selected at appropriate growth stages to record observations on morphological traits namely, initiation of flowering, 50% flowering, maturity, plant height, primary branches and secondary branches per plant, main shoot length, siliquae on main shoot, siliqua length, and seeds per siliqua. Post harvest observations include seed yield per plant, 1000-seed weight, harvest index and quality traits such as oil and protein content. The mean values of five plants for each character were considered for computation, except for days to flower initiation, 50 % flowering and days to maturity (which was recorded on whole plot basis). 1000-seed was counted by electronic seed counter (Contador, Germany) and weighed by electronic balance. Further, oil and protein content were analyzed by Near Infrared Reflectance Spectroscopy, (Dickey- John, Instalab 600). The mean data were subjected for analysis of variance, the data analyzed by using software Statistical Package for Augmented Design (SPAD) of IASRI, New Delhi, India. Phenotypic (PCV) and genotypic coefficient of variance (GCV) were calculated using formula suggested by Burton (1952)**,** heritability (h^2) in broad sense and expected genetic advance as percent of mean at 5% intensity of selection differential were calculated for each character as suggested by Johnson *et al.* (1955) and correlations coefficient were calculated according to the procedure of Singh and Chaudhary (1977).

Results and Discussion

Analysis of variance (Table 1) for seed yield and its related components showed that there is significant variability among accessions for initial flowering, 50% flowering, plant height, primary and secondary branches per plant, main shoot length, siliquae on main shoot, seeds per siliqua, 1000-seed weight, siliqua length, harvest index, oil content and seed yield per plant, suggesting that the material has adequate variability to support the breeding programme for improving the seed yield. The blocks showed the intermingling relationship of significant and non-significant for the traits indicating lack of homogeneity among the blocks. The check versus genotype interaction showed high significance for initial flowering, plant height, siliqua on main shoot and seeds per siliqua. This indicates difference between check as a group and genotype as another group.

The range, mean, genotypic and phenotypic coefficient of variation (GCV and PCV), heritability in broad sense and genetic advance expressed as percentage of mean value for different characters are presented in Table 2. The PCV was greater than GCV for all the characters indicating the influence of the environment in the expression of these traits. The maximum PCV was observed in seed yield per plant (44.8%) and followed by seeds per siliqua (25.2%), secondary branches per plant (24.8%) and harvest index (23.9%). The PCV varied from 2.9% (oil content) to 44.8% (seed yield per plant). The maximum GCV was found in seed yield per plant (35.0%) and followed by harvest index (20.2%), seeds per siliqua (19.9%) and siliquae on main shoot (16.9%). The rest of the characters showed low PCV and GCV. High PCV and GCV for seed yield per plant, secondary branches per plant, seed per siliqua and harvest index were reported in oilseed brassicas (Mondal and Khajuria, 2000; Sikarwal *et al.,* 2000; Mahala *et al.,* 2003; Meena *et al.,* 2006)

Heritability is important selection parameter, since it is estimated from additive genetic variance, it plays important role in the selection of genotypes (Nadarajan and Gunasekaran, 2005). High heritability (i.e. broad sense value >60) values were observed for initial flowering, 50% flowering, plant height, siliqua length, harvest index, 1000-seed weight, seeds per siliqua and seed yield per plant. High genetic advance is another parameter to access the expected improvement in a character by hybridization and selection. High values for genetic advance were recorded for plant height, siliquae on main shoot, seeds per siliqua, 1000-seed weight, seed yield per plant and harvest index. In the present study, high heritability coupled with high genetic advance was observed for plant height, seeds per siliqua, 1000-seed weight, seed yield per plant and harvest index. Similar trends have also been reported by various other workers in *Brassica* spp (Uddin *et al.,* 1995; Pant and Singh, 2001; Pandey and Singh, 2002; Mahala *et al.,* 2003).

Correlation estimates between seed yield and other morphological traits are useful in selection of desirable plant type in designing an effective breeding programme. Seed yield is a complex phenomenon which is encompassing the interactions between many yield contributing traits. Therefore, selection should be based keeping in view these traits and their correlation with seed yield (Grafius, 1964). The correlation coefficients with seed yield *vis-a-vis* other yield contributing traits and their all possible interrelationship were depicted in Table 3. The seed yield per plant was positively and significantly correlated with main shoot length, siliquae on main shoot, primary branches per plant, oil content, 1000-seed weight, harvest index and days to maturity, while remaining characters observed non-significant correlations except for two characters. Seeds per siliqua and protein content showed negative but significant correlations with seed yield per plant. Seeds per siliqua showed positive and significant correlations with initiation of flowering, 50% flowering and siliqua length. Significant positive correlations of harvest index with 1000-seed weight and oil content. Similarly, significant positive correlations was recorded in siliquae on main shoot with main shoot length and plant height; oil content with 1000-seed weight; plant height with initiation of flowering and 50% flowering; siliqua length with plant height and primary branches per plant with plant height. Hence, selection for the higher values of these traits will be desirable for increase seed yield. The associations between the yield related attributes reveal the mutual relationship between two or more characters; therefore, it is an important parameter for taking a decision regarding the selection and its further utilization in improvement in the crop. This is in conformant of some of the earlier reports on *Brassica* (Yadav *et al*., 2001; Kumar *et al*., 2001; Patel and Patel, 2005; Misra 20111,Misra *el al.,* 2007a, b, 2010).

Promising donors were identified for various seed yield contributing traits which are to be useful donors in the variety development programme. Accession IC 361512 identified as a useful donor for early flowering, high harvest index, more number in primary branches and secondary branches per plant (Table 4). The accessions IC 342762 and IC 334290 were recorded for more number of siliquae on main shoot and long main shoot length. Accession IC 355382 had high oil content and 1000-seed weight, further IC 520748 showed more seeds per siliqua and primary branches per plant. Besides this accession IC 355365 had long siliqua and high harvest index and IC 447818 recorded for short plant height and high number of primary branches per plant. Highest seed yield per plant (21.9 g), 1000-seed weight (5.1 g) and number of seeds per siliqua (48.9) recorded in accession IC 336456, IC 361508 and IC 447740, respectively.

On the basis of different variability parameters and correlation data, the present investigation revealed that there is an adequate variability for siliquae on main shoot, main shoot length, 1000-seed weight, seeds per siliqua and harvest index in the indigenously collected germplasm of *Brassica rapa* var. *yellow sarson*. The promising accessions can be used directly for hybridization and other breeding strategy related to genetic enhancement of yellow sarson. It may be concluded that characters such as seeds per siliqua, siliquae on main shoot, oil content, harvest index, 1000-seed weight and seed yield per plant will help in improving the seed yield directly and indirectly. Therefore, these characters should be considered for seed yield improvement in yellow sarson breeding programmes.

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Table 1. Analysis of variance for different agro-morphological traits in yellow sarson

Sl. No.	Characters	Mean sum square due to			
		Blocks	Checks	Entries	Checks Vs entries
	Degree of freedom	**4**	**3**	**68**	**1**
1	Initial flowering	29.1	149.4*	39.3**	128.9*
2	50% flowering	41.3	132.9*	31.0**	57.1
3	Plant height (cm)	9995.4**	563.7	309.5**	4556.7**
4	Primary branches per plant	0.25	10.9*	1.1*	14.5
5	Secondary branches per plant	0.33	0.31	0.56*	3.9
6	Main shoot length (cm)	9.7	163.4	44.6*	2.0
7	Siliquae on main shoot	18.1	11.4	28.0**	103.6*
8	Siliqua length (cm)	0.08	0.78*	0.22**	2.2
9	Seeds per siliqua	29.2	102.1	57.1**	381.6*
10	1000-seed weight (g)	1.1*	1.27*	0.39**	1.2
11	Harvest index (%)	54.8*	69.7	32.6**	37.2
12	Maturity	452.6*	28.8	58.0	29.3
13	Protein content (%)	0.18	0.83	0.4	4.7
14	Oil content (%)	2.41	1.9	1.5**	13.5
15	Seed yield per plant (g)	2.3	11.5	16.7**	4.0

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

Table 2. Mean, range, genotypic and phenotypic coefficient of variation, heritability and genetic advance for different traits in yellow sarson

Characters	Mean	Range	GCV %	PCV %	Broad sense Heritability (%)	Genetic Advance (%)
Initial flowering	47.0	35.0-53.0	11.1	13.3	69.7	19.2
50% flowering	53.7	33.0-64.0	8.6	10.4	68.1	14.5
Plant height (cm)	100.3	69.4-152.3	14.0	17.5	64.1	23.2
Primary branches per plant	4.5	2.6-6.8	15.0	23.3	41.8	20.0
Secondary branches per plant	3.0	1.9-5.6	15.5	24.8	39.3	20.1
Main shoot length (cm)	44.5	36.9-72.2	10.2	15.0	46.2	14.3
Siliquae on main shoot	24.0	18.3-45.3	16.9	22.0	58.6	26.6
Siliqua length (cm)	3.8	2.8-4.9	10.1	12.2	68.2	17.2
Seeds per siliqua	29.6	15.9-45.9	19.9	25.5	60.8	32.0
1000-seed weight (g)	3.2	8.9-31.5	15.5	19.7	61.5	25.0
Harvest index (%)	23.9	8.2-32.6	20.2	23.9	71.8	35.3
Maturity	117.0	102.0-135.0	4.2	6.5	42.4	5.7
Protein content (%)	20.1	17.9-22.9	2.4	3.1	57.5	3.7
Oil content (%)	42.7	39.6-45.6	2.2	2.9	58.7	3.5
Seed yield per plant (g)	9.1	5.3-25.3	35.0	44.8	61.1	56.3

Table 3. Estimates of phenotypic correlation coefficient in different traits in yellow sarson

Characters	#IF	FF	PH	PB	SB	MSL	SMS	SL	SPS	SW	PC	OC	HI	DM
FF	0.866**													
PH	0.297*	0.325**												
PB	-0.004	-0.064	0.404**											
SB	0.021	0.037	0.244*	0.456**										
MSL	0.136	0.124	0.302**	0.148	0.099									
SMS	0.117	0.117	0.388**	0.128	0.189	0.683**								
SL	0.017	0.080	0.272*	-0.049	-0.074	-0.102	-0.047							
SPS	0.407**	0.428**	0.026	-0.132	-0.130	-0.201	-0.199	0.282*						
SW	-0.163	-0.177	-0.618**	-0.373**	-0.227	0.153	-0.021	-0.139	-0.143					
PC	0.085	0.086	0.192	0.015	0.198	-0.005	0.154	-0.271*	0.150	-0.290*				
OC	-0.135	-0.111	-0.547**	-0.260*	-0.278*	-0.021	-0.186	0.076	-0.184	0.676**	-0.606**			
HI	-0.142	-0.141	-0.275*	0.104	0.110	0.223	0.150	-0.014	-0.202	0.496**	-0.287*	0.632**		
DM	-0.174	-0.180	-0.665**	-0.360**	-0.199	0.266*	0.089	-0.290*	-0.288*	0.830**	-0.302**	0.609**	0.493**	
SYP	0.061	0.057	0.097	0.267*	0.166	0.514**	0.379**	0.006	-0.327**	0.308**	-0.329**	0.376**	0.610**	0.315**

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

#*IF: Initiation of flowering, FF: 50% flowering, PB: Primary branches per plant, SB: Secondary branches per plant, MSL: Main shoot length, PH: Plant height, SMS: Siliquae on main shoot, DM: Maturity duration, SL: Siliqua length, SYP: Seed yield per plant (g), SPS: Seeds per siliqua, HI: Harvest index, SW: Seed weight, PC: Protein content and OC: Oil content*

Table 4. Promising accessions of yellow sarson

Characters	Promising Accessions
Initiation of flowering	**< 47:** IC 331817, IC 342766, IC 361510, IC 361512
50 % flowering	**< 53:** IC 331817, IC 334283, IC 334291, IC 520823
Plant height	**> 118:** IC 447818, IC 447822, IC 520757, IC 521379
Primary branches per plant	**> 5.4:** IC 361512, IC 447818, IC 520748, IC 520749
Secondary branches per plant	**> 3.5:** IC 355391, IC 355397, IC 361512, IC 520748
Main shoot length	**> 50.5:** IC 334290, IC 336456, IC 342762, IC 342768
Siliquae on main shoot	**> 28.0:** IC 336456, IC 342760, IC 342762, IC 361506
Siliqua length	**> 4.1:** IC 342766, IC 355365, IC 520755, IC 520771
Seeds per siliqua	**> 39.0:** IC 447740, IC 447824, IC 520315, IC 520748
1000-seed weight	**> 3.04**: IC 355412, IC 355368, IC 355382, IC 361508
Seed yield per plant	**> 17.7:** IC 336456, IC 355419, IC 520771
Harvest index	**> 25.1:** IC 334200, IC 334290, IC 355365, IC 361512
Oil content	**> 42.7:** IC 342283, IC 355307, IC 355312, IC 355368, IC 355378, IC 355382

Heterosis studies for yield and contributing characters in Indian cauliflower

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Abstract

Six crosses involving four parents were assessed for heterotic performance in Indian cauliflower. The parents involved were highly divergent for the traits studied. The hybrids Pusa Himjyoti X BR-207 and Pusa Sharad X BR-207 exhibited significant heterosis over mid and better parent for most of the characters having potential for commercial exploitation.

Introduction

Cauliflower is one of the major vegetable crops grown in India. Most of the released open pollinated varieties are poor in curd quality coupled with low yield besides lacking uniform maturity. The emphasis, therefore, has been on developing F_1 hybrids which are uniform, having good quality curd and high yielding. Yield is a complex character influenced by various component characters, especially curd weight, curd diameter, curd depth etc. These are inherited polygenically and are subjected to environmental variations. Crop breeding for picking up useful characters and putting them up together to develop a variety having desirable traits need the knowledge of gene action of these characters. Heterosis breeding is one of the commonly known methods of increasing productivity, but has been reported to be less in Snowball cauliflower (Watts, 1965, Swarup and Pal, 1966). However, Indian cauliflower originating from Cornish types through spontaneous mutation and human selection are highly divergent and are endowed with high heterotic potential. The presence and exploitation of heterosis in early maturity group of Indian cauliflower have been reported earlier by various workers (Singh *et al*., 1976; Upadhyaya *et al*., 1983; Varalakshmi, 2009). The present study was undertaken to know the heterotic for curd traits in Indian cauliflower with the view to exploit it commercially.

Materials and methods

The materials for the present investigation consisted of four inbred lines, namely Pusa Himjyoti, Pusa Sharad, BR-161 and BR-207. These were crossed in all possible combinations excluding reciprocals. All the six F_1 hybrids and four parents were raised in a randomized block design with three replications during 2009-2010. There were 20 plants in each of the parents and F_1 hybrids in each replication planted at 45 x 45 cm spacing. The recommended packages of practices were followed for raising the crop. The observations were recorded on ten randomly selected plants for plant height, leaf number, curd weight, curd depth and curd diameter. Heterosis was calculated as the per cent increase in F_1 over mid parent and better parent. The data were analysed by WINDOWSTAT (WINDOWSTAT, 2003) programme.

Result and Discussion

The parents involved in the present study were divergent. Heterosis was highly pronounced in respect of plant height, leaf number, curd weight, curd diameter and curd depth. The mean values of parents and F_1s for different curd characters are presented in table 1. In the entire cross combinations, the F_1 hybrids' average performance was better than the mean value of the parents. The mean values of F_1s were highest for curd weight (934.70 g) and curd diameter (14.62 cm) in combination Pusa Himjyoti X BR-207 and for curd depth (11.71 cm) in Pusa Sharad X BR-161. The heterosis for curd weight over mid (101.29) and better parent (74.62) was highest in cross combination Pusa Himjyoti X BR-207 followed by Pusa Himjyoti X BR-161 and Pusa Sharad X BR-161. This combination also registered higher heterosis for curd diameter and curd depth over both mid and better parent (Table 1). Sandhu *et al.* (1977) also reported high standard heterosis in two crosses for curd weight over standard check in cauliflower. The favourable traits for selection are less number of leaves, larger curd size and higher curd weight. Among the parents, Pusa Sharad was having maximum curd weight. In the F_1 hybrids, there was marked heterosis for all the characters which suggests that heterosis breeding programme can be taken up for commercial exploitation in Indian cauliflower.

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Table1. The mean values of parents and F_1 hybrids and heterosis % over mid parent

Crosses and parents	**Plant height (cm)**			**Number of leaves**			**Curd weight (g)**			**Curd diameter (cm)**			**Curd depth (cm)**		
	Means	**Heterosis over MP**	**Heterosis over BP**	**Means**	**Heterosis over MP**	**Heterosis over BP**	**Means**	**Heterosis over MP**	**Heterosis over BP**	**Means**	**Heterosis over MP**	**Heterosis over BP**	**Means**	**Heterosis over MP**	**Heterosis over BP**
Crosses															
PH x BR-161	60.67	20.83	18.89	25.93	18.46	16.06	879.33	87.53	64.27	14.13	50.31	45.07	9.14	45.07	41.04
PH x BR-207	65.41	28.03	27.87	24.73	9.33	3.95	934.70	101.29	74.62	14.62	54.05	50.10	10.73	88.15	75.32
PS X BR-161	60.72	16.37	10.44	26.60	16.06	13.91	929.16	85.37	54.86	14.28	42.08	29.46	11.71	54.89	35.53
PS X BR-207	62.10	17.04	12.95	22.66	-4.14	-4.74	904.66	82.13	50.77	13.18	30.05	19.49	10.08	44.82	16.66
BR-161 X BR-207	58.53	16.43	14.42	25.00	8.41	5.08	523.33	31.50	30.01	10.88	18.85	17.74	7.98	35.71	23.14
PH X PS	58.57	10.51	6.52	25.40	13.04	8.08	859.16	51.35	43.19	13.38	28.85	37.37	9.74	31.97	50.3
Parents															
PH	51.03			21.45			535.27			9.74			6.12		
PS	54.98			23.50			599.99			11.03			8.64		
BR-161	49.39			22.34			402.50			9.07			6.48		
BR-207	51.15			23.79			393.41			9.24			5.29		

PH: Pusa Himjyoti; PS: Pusa Sharad; MP: Mid parent; BP: Better parent

Studies on combining ability and heterosis for yield and oil content in Indian mustard

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Abstract
Investigation was undertaken to study the combining ability and to quantify the magnitude of heterosis of G x E interaction were carried out at three dates of sowing in North-South sowing direction and three dates of sowing in East-West sowing direction for grain yield and yield attributes along with one quality character i.e. oil content in percent in 36 single cross hybrids developed using 9 x 9 diallel set (excluding reciprocals) on Indian mustard (*Brassica juncea*), both additive and non-additive gene effects were important. From this study it is inferred that the change in sowing direction showed selective sensitivity of gca and sca of yield and yield traits. RW873 was the best general combiner for days to 50% flowering, plant height, days to maturity and harvest index in North-South and East-West sowing directions. None of the crosses showed high sca for both North-South and East-West sowing directions for all traits. The crosses selected for seed yield/plant (RW29-6-3 x Vardan and PR 18 x BR40) and for oil content in *per cent* (RW873 x Vardan, Kranti x BR40 and RH843 x BR40) showed high desirable sca effects in both sowing directions. The heterosis over mid-, better- and best- parent, the crosses RW873 x BR40 for heterosis over mid- and better-parent in North-South, PR830 x PR18 and PR830 x Vardan for heterosis over best-parent in North-South, PR830 x Kranti for heterosis over mid-parent in East-West, RW873 x PR18 for heterosis over better-parent in East-West and Kranti x RH851 for heterosis over best-parent in East-West were promising. None of the crosses expressed heterosis over mid-, better- and the best- parent in both North-South and East-West sowing directions for all the characters. These hybrids can be exploited as better hybrids for commercialization across the wide environments through heterosis breeding and also for the deviation of inbred lines in segregating generations.

Key words: Mustard, combining ability, gca, sca, Heterosis (over mid-, better- and best parent), sowing direction (North-South and East-West).

Introduction

Indian mustard is highly priced oilseed crop and is cultivated either sole or as inter-crop under irrigated or rainfed condition. Combining ability analysis is utilized to assess the nicking ability of genotypes and helps in identifying parents, which are likely to be successful to get desirable segregates in a hybridization program. The nature of genetic variation present in the base population is known genetic evaluation through various genetic parameters. In heterosis breeding programme, knowledge on extent of heterosis is not only helpful to identify high yielding cultivars but also substantiates the nature of heterosis. An understanding of the susceptibility of these genetic parameters and the extent of heterosis for seed yield along with other traits in selected cross combinations in Indian mustard to change in sowing directions may be of great importance to a breeder to initiate a successful breeding program. In the present study an effort has been made to find out the genetic components and extent of heterosis of seed yield and its attributes and to formulate effective breeding strategy to improve seed yield along with other traits in Indian mustard.

Materials and Methods

Nine parents (RW873, PR830, Kranti, RW29-6-3, PR18, RH843, RH851, Vardan and BR40 were involved in a diallel mating design (excluding reciprocals). Forty-five genotypes were grown on three dates (E_1 and E_4 on 27th September, E_2 and E_5 on 4th October and E_3 and E_6 on 11th October 1997) at North-South (E_1, E_2 and E_3) and

East-West (E_4, E_5 and E_6) sowing directions with two replications on each date during winter at Birsa Agricultural University experimental area, Ranchi. The area is located between 23°17" latitude and 85"19'E longitude and altitude is 625 meters above the mean sea level. The p^H of the soil is being 5.9. The distance between rows and plants were maintained at 30 and 10cm, respectively. Cultural practices as recommended for the area were followed. Ten competitive plants were randomly selected from each lines, replication and six environments to record the observations on 11 characters (Table 1). Analysis were done following Griffing [1] for combining ability and; following Hayes *et al.*, [2] and Rai [3] for heterosis (mid parent, better parent and best parent).

Results and Discussion

(i) General and Specific combining ability in North-South and East-West sowing direction: The mean squares due to general combining ability (**gca**) were significant for all characters studies in all sowing directions, whereas the mean squares associated with specific combining ability (**sca**) were non-significant for primary and secondary branches/plant in North-South sowing and, plant height and days to maturity in East-West sowing direction, thus, indicating the importance of both additive as well as non-additive gene effects for these traits and presence of significant genotypes x sowing direction interactions.

Pooled analysis of variance, it was observed that both **gca** and **sca** mean squares were significant for most of the characters. The earlier Labana *et al.,* [4]**,** Yadav *et al.,* [5] and Kumar *et al.*, [6], reported similar results in single environment, whereas Kumar and Yadav [7] supported the present findings in different environments.

Sowing direction x **gca** interactions were significant for most of the characters. Sowing direction x **sca** interactions were significant for all characters, except, plant height. Therefore, the change in sowing direction showed selective sensitivity of **gca** and **sca.**

On the examination of **gca** effects and *per se* performance, it was revealed that none of the parental genotype has desirable **gca** and *per se* performance for all these traits. The parental genotype RW 873 was the best general combiner for days to 50 % flowering, plant height, days to maturity and harvest index in North-South and East-West sowing direction. Whereas it is good combiner for North-South sowing direction for days to 50% flowering, plant height, days to maturity, harvest index and oil content in per cent. RW873 is also good combiner for East-West sowing direction for days to 50% flowering, plant height, days to maturity, harvest index, 1000-seed weight and seed yield/ plant (table 1). None of crosses showed high **sca** in North-South and East-West directions for most of the characters. Among the crosses selected for 1000 seed weight (PR830 x Vardan), seed yield/Plant (RW29-6-3 x Vardan and PR18 x BR40) and oil content (RW873 x Vardan, Kranti x BR 49 and RH843 x BR40) were the best crosses having high desirable **sca** effects in both North-South and East-West sowing directions.

(ii) Heterosis over mid parent, better parent and best parent in North-South and East-West sowing direction: Among the all-36 crosses, RW873 x BR40 showed significant heterosis over mid-parent for number of primary and secondary branches/plant, number of siliquae/plant, number of seeds/siliqua, 1000-seed weight, harvest index, seed yield/plant and oil content in North-South sowing direction. Other promising crosses were RW873 x RH843, RW873 x RH851 and Vardan x BR40. None of the crosses showed significant heterosis over mid-parent for all the characters in North-South sowing direction. Out of 36 crosses, RW873 x BR40 expressed high significant heterosis over better parent for number of primary and secondary branches/plant, number of siliquae /plant, number of seeds/siliqua, 1000-seed weight, harvest index, seed yield/plant and oil content in North-South sowing direction. Other promising crosses were RW873 x RW29-6-3, RW873 x RH851, RW29-6-3 x Vardan, PR830 x PR18, PR830 x RH851, PR830 x Vardan, PR830 x BR40 and Kranti x Vardan for heterosis over better parent in North-South sowing direction. None of these crosses showed significant heterosis over better parent for all the characters in North-South sowing direction.

The cross PR830 x PR18 had high significant heterosis over the best parent in North-South sowing direction for 1000-seed weight and harvest index. None of the crosses had significant heterosis over the best parent for all the characters in North South sowing direction**.** The cross PR830 x Kranti showed significant heterosis over mid-parent for number of primary and secondary branches/ plant, number of seeds/siliqua, 1000-seed weight, harvest index, seed yield/plant and oil content in East-West sowing direction. The crosses RW873 x PR830, RW873 x RW29-6-3, PR830 x RW29-6-3, PR830 x RH843, PR830 x RH851, PR830 x BR40, Kranti x RW29-6-3, Kranti x PR18, Kranti x Rh851, RW29-6-3 x BR40, PR18 x BR40, Rh843 x BR40, RH851 x BR40 were promising for heterosis over mid-parent in East-West sowing direction in Indian mustard. None of crosses showed significant heterosis over mid-parent for all the characters in East-West sowing direction.

Among the 36 crosses, the cross RW873 x PR18 expressed significant high heterosis over better parent for number of primary and secondary branches/plant, number of seeds/siliqua, 1000-seed weight and harvest index in East-West sowing direction. The crosses RW873 x PR830, PR830 x RW29-6-3, PR830 x BR40, RH843 x Vardan and RH851 x BR40 were promising for heterosis over better parent in East-West sowing direction in Indian mustard. None of the crosses showed significant heterosis over better parent for all the characters in East-West sowing direction.

The crosses Kranti x RH851 had significant heterosis over the best parent for the number of primary and secondary branches/plant, number of seeds/siliqua, 1000-seed weight, harvest index, seed yield/ plant and oil content in East-West sowing direction. The crosses Kranti x RW29-6-3, RW873 x RH843, RW29-6-3 x RH851 and RH843 x Vardan were promising for heterosis over the best parent in East-West sowing direction in Indian mustard. None of the crosses was expressed significant heterosis over the best parent for all the characters in East-West sowing direction.

None of the crosses was showed significant heterosis over mid-, better- and best- parent for all the characters in both North-South and East-West sowing directions.

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Table 1. General Combining ability in Indian mustard for different traits in North-South and East-West sowing directions.

Crosses		1	2	3	4	5	6	7	8	9	10	11
RW873	NS	$\underline{**}$			$\underline{**}$	$\underline{**}$		$\underline{**}$	**			**
	EW	**	*		**			*	**	*	**	
PR830	NS	**										
	EW											
KRANTI	NS									**	*	
	EW						$\underline{*}$				$\underline{**}$	**
RW29-6-3	NS	**	*	**								**
	EW						*	**				**
PR18	NS			$\underline{*}$	*							$\underline{**}$
	EW	**			*							*
RH843	NS		*		**	*			$\underline{*}$			**
	EW		**	**	**	**				*	**	
RH851	NS	**						*				**
	EW	**							*			
VARDAN	NS			**							$\underline{*}$	*
	EW	*			*		**	**				
BR40	NS	$\underline{*}$							**		**	
	EW				$\underline{**}$	$\underline{*}$				$\underline{**}$		*

*, ** Significant at 5 and 1% probability levels, respectively ($\underline{*}$, $\underline{**}$ for negative). EW is East-West sowing direction and NS is North-South sowing direction.

CHARACTERS: 1. Days to 50% flowering, 2.Primary branches/plant, 3.Secondary branches/plant, 4.Plant height (cm), 5.Number of siliquae/ plant, 6.Number of Seeds/siliqua, 7.Days to maturity, 8.Harvest index, 9.1000-Seed weight (g), 10.Seed yield/plant (g) and 11.Oil content (%).

Table 2. Specific combining ability in Indian mustard for different traits in North-South and East-West sowing directions.

Crosses		Characters 1	2	3	4	5	6	7	8	9	10	11
RW873 x PR830	NS				*̲			*				*
	EW	*̲*̲							**			*̲*̲
RW873 x KRANTI	NS							*̲*̲			**	
	EW											
RW873 x RW29-6-3	NS	*̲*̲						*̲*̲				
	EW					**	*̲				**	
RW873 x PR18	NS											*̲*̲
	EW				*		*̲*̲	*̲	*̲*̲	**	**	
RW873 x RH843	NS		*̲		*̲					*		*̲*̲
	EW						*			*		*̲
RW873 x RH851	NS	*				*		**				*
	EW											
RW873 x VARDAN	NS											**
	EW											**
RW873 x BR40	NS	*̲*̲	**	*	**							
	EW	**	*̲	*̲	*̲*̲				*̲*̲			*̲*̲
PR830 x KRANTI	NS			*̲	*̲	*̲			*̲*̲	*̲*̲	*̲*̲	
	EW											**
PR830 x RW29-6-3	NS				*̲		*		**			
	EW								*̲*̲			**
PR830 x PR18	NS					**						*
	EW											
PR830 x RH843	NS								*̲*̲			**
	EW		*			*					*	*̲*̲
PR830 x RH851	NS		**	**		**					**	*̲*̲
	EW											*̲*̲
PR830 x VARDAN	NS	**		*̲		*̲	*̲	*	*	**		
	EW						**			**		*̲*̲
PR830 x BR40	NS				*̲		*̲*̲		**			
	EW							*				**
KRANTI x RW29-6-3	NS											*̲
	EW				*		**			*		
KRANTI x PR18	NS	*̲					**					**
	EW				*̲							
KRANTI x RH843	NS	*						*				**
	EW					*̲	*̲				*̲	
KRANTI x RH851	NS											
	EW							*		*		*̲*̲
KRANTI x VARDAN	NS	**	**			*						*̲*̲
	EW							**				
KRANTI x BR40	NS								*̲*̲	**	*̲*̲	**
	EW				*		*̲*̲		*̲*̲			**
RW29-6-3 x PR18	NS								*̲*̲			
	EW										*̲*̲	**
RW29-6-3 x RH843	NS			*		**					**	*̲*̲
	EW					*̲					*̲*̲	*
RW29-6-3 x RH851	NS				*̲*̲				*̲			*
	EW	*							*̲			
RW29-6-3 x VARDAN	NS				**					**	*	
	EW						*̲*̲				**	*̲
RW29-6-3 x BR40	NS	**			*̲*̲	*̲					*̲	
	EW	*̲			*̲							
PR18 x RH843	NS		*̲*̲	*̲	*̲*̲	*̲*̲			**			**
	EW		*̲									
PR18 x RH851	NS										*	
	EW						*̲		*̲			*
PR18 x VARDAN	NS			*̲		*̲						*̲*̲
	EW							*̲				*̲*̲
PR18 x BR40	NS					*̲*̲					**	**
	EW		**	**		**	**		**		**	
RH843 x RH851	NS				**							*̲*̲
	EW			*		**		*̲*̲				
RH843 x VARDAN	NS		**									
	EW			**		*					**	**
RH843 x BR40	NS											**
	EW		**		*							*
RH851 x VARDAN	NS											*̲
	EW			*̲					*			**
RH851 x BR40	NS											
	EW	*̲*̲		**	*		**	*̲	*			
VARDAN x BR40	NS	*̲		**		**		*̲				
	EW						*̲					*̲*̲

*, ** Significant at 5 and 1% probability levels, respectively (*̲, *̲*̲ for negative). EW is East-West sowing direction and NS is North-South sowing direction.

CHARACTERS:1.Days to 50% flowering, 2. Primary branches/plant, 3.Secondary branches/ plant, 4.Plant height (cm), 5.Number of siliquae/ plant, 6.Number of Seeds/siliqua, 7.Days to maturity, 8.Harvest index, 9.1000-Seed weight (g), 10.Seed yield/plant (g) and 11.Oil content (%).

Table 3. Heterosis (over mid-, better- and best- parent) in Indian mustard for different characters in North-South and East-West sowing directions.

Crosses		1	2	3	4	5	6	7	8	9	10	11
RW873 x PR830	NM	**	**	**			**		**	**	*	
	NB	**	**	**							*	
	NT	**	**	**			**		**	**	*	*
	EM		**	**			**		**	*	*	**
	EB											
	ET	**							**			**
RW873 x KRANTI	NM	*	**	**			**		**	**		
	NB	**	**				**		**	**		
	NT	**	**	**			**		**	**		**
	EM	**	**	**			**		**	**		**
	EB	**	**	**			**		**	**		**
	ET	**	**	**			**		**	**		**
RW873 x RW29-6-3	NM		**	**			**	**	**	**		
	NB		**	**			**	*	**	**		*
	NT		**	**			**	*	**	**	*	**
	EM	**	**	**			**		**	**		*
	EB						**		**	**		**
	ET		**	**			**		**	**		**
RW873 x PR18	NM		**	**			**		**	**		*
	NB		**	**			**		**	**		*
	NT	*	**	**			**		**	**		**
	EM	**	**				**		**	**		
	EB	**	**	**			**		**	**		
	ET	**	**	**			**		**	**		**
RW873 x RH843	NM		**	**			**		**	**		**
	NB	**	**	**	*		**					**
	NT	**	**	**	*		**		**	**		**
	EM	**	**						**	**		*
	EB	**	**				**		**	**		*
	ET	**	**	**			**		**	**		**
RW873 x RH851	NM		**	**			**		**	**		*
	NB			**			**		**	**		**
	NT	*	**	**			**		**	**		**
	EM		**				*		**	**		
	EB	**	**				**		**	**		
	ET	**	**	**			**		**	**		**
RW873 x VARDAN	NM		**	**			*		**	**		
	NB		**	**			**		**	**		
	NT		**	**			**		**	**		
	EM	**	**	**					**			
	EB	**	**	**			**		**	**		
	ET	**	**	**			**		**	**		**
RW873 x BR40	NM		**	**		**	**		**	**	**	**
	NB		**	**		*	**		**	**	**	**
	NT		**	**					**	**		*
	EM	**	**	**			**		**	**	**	**
	EB	**	**	**			**		**	**	*	**
	ET	**	**	**	*		**		**	**		**
PR830 x KRANTI	NM		**	**			**		**	**	**	*
	NB		**	**			**		**	**	**	*
	NT	*	**	**			**		**	**	**	*
	EM	**	**	**			**		**	**	**	*
	EB	**					**		**	**	**	**
	ET	**	**	**			**		**	**	**	**
PR830 x RW29-6-3	NM		**	**			**		**	**	*	**
	NB		**	**					**	**	**	**
	NT		**	**					**	**	**	**
	EM		**	**		**	**		**	**	**	
	EB		**	**		**	**		**	**	**	**
	ET	**	**	**			**		**	**	**	**
PR830 x PR18	NM						**		**	**		
	NB						**		**	**		
	NT		**	**			**		**	**		*
	EM	*	**	**					**	**	**	*
	EB		**				**		**	**	**	
	ET		**	**			**		**	**	**	
PR830 x RH843	NM	**	**	**			**		**	**		**
	NB	**	**	**			**		**	**		**
	NT	**	**	**			**		**	**		**
	EM		*	**			**		**	**	**	**
	EB		**	**			**		**	**	**	**
	ET	**	**	**			**		**	**	**	**
PR830 x RH851	NM		**				**		**	**	**	**
	NB	*	**				**		**	**	**	**
	NT	**	**	**			**		**	**	**	**
	EM		**	*					**	**		
	EB		**	**			**		**	**		*
	ET	**	**	**			**		**	**		**
PR830 x VARDAN	NM	**	**	**			**		**	**	**	
	NB	**	**	**			**		**	**	**	
	NT	**	**	**			**		**	**	**	
	EM	**	**	**			**		**	**		**
	EB	**	**	**			**		**	**		**
	ET	**	**	**			**		**	**		**
PR830 x BR40	NM		**	**			**		**	**		**
	NB		**				**		**	**		**
	NT	*	**	**			**		**	**		
	EM	*	**	**			**		**	**		**
	EB	**	**	**			**		**	**		
	ET	**	**	**			**		**	**		**
KRANTI x RW29-6-3	NM	**	**	**			**		**	**	**	**
	NB	**	**	**			**		**	**		**
	NT	**	**	**			**		**	**		**
	EM	**	**	**			**		**	**	**	**
	EB	**	**						**	**	**	**
	ET		**	**			**		**		**	**
KRANTI x PR18	NM		**	**			**		**	**	*	**
	NB		**	**			**		**	**		
	NT		**	**			**		**	**		*
	EM		**				**		**	**		*
	EB								**	**		**
	ET	**	**	**			**		**	**		**
KRANTI x RH843	NM	**	**	**	*		**		**	**		
	NB	**	**	**	*		**		**	**		**
	NT	**	**	**	*		**		**	**		**
	EM	**	**				**		**	**		
	EB	**	**	*			**		**	**		
	ET	**	**	**			**		**	**		
KRANTI x RH851	NM		**	**			**		**	**		**
	NB		**	**			**		**	**		**
	NT		**	**			**		**	**		**
	EM	*	**	**			**		**	**	**	**
	EB	**		**					**	**	**	**
	ET	**	**	**			**		**	**	**	**
KRANTI x VARDAN	NM	**	**	**			**		**	**		**
	NB	**	**	**			**		**	**		**
	NT	**	**	**			**		**	**		**
	EM		**	**			**		**	**		**
	EB	*	**	**			**		**	**		**
	ET	**	**	**			**		**	**		**
	NM	**	**	**			**		**	**		*
	NB		**	**			**		**	**		
	NT		**	**			**		**	**		**

	EM		**	**			**		**	**	**	**
	EB		**	**			**		**	**	**	**
	ET	**	**	**			**		**	**	**	**
RW29-6-3 X PR18	NM	**	**	**					**	**		
	NB	**	**	**					**	**		
	NT	**	**	**			**		**	**	*	**
	EM		**				**		**	**		
	EB		**				**		**	**	**	
	ET	**	**	**			**		**	**	**	
RW29-6-3 X RH843	NM		**	**			**		**	**	*	**
	NB		**	**			**		**	**		**
	NT		**	**			**		**	**		**
	EM		**	**					**	**	*	
	EB			**			**		**	**		
	ET	**		**			**		**	**	**	**
RW29-6-3 X RH851	NM		**	**			**		**	**		
	NB		**	**			**		**	**		
	NT		**	**			**		**	**		
	EM		**	**			**		**	**	**	
	EB		**	**			**		**	**	**	*
	ET	**	**	**			**		**	**	**	**
RW29-6-3 x VARDAN	NM	**	**	**			**		**	**		**
	NB	**	**	**			**		**	**		**
	NT	**	**	**			**		**	**		**
	EM			**			**		**	**		**
	EB		**	**			**		**	**		**
	ET	**	**	**			**		**	**		
RW29-6-3 X BR40	NM		**	**			**		**	**		
	NB		**	**			**		**	**		**
	NT	*	**	**			**		**	**	*	**
	EM	**	**				**		**	**		**
	EB	*	**	**			**		**	**		**
	ET	*	**	**			**		**	**		**
PR18 x RH843	NM		**	**			**		**	**		
	NB		**	**			**			**		
	NT		**	**			**			**	*	**
	EM		**	**			**			**		
	EB		**	**			**		**	**		
	ET	**	**	**					**	**		**
PR18 x RH851	NM		**	**			**		**	**		
	NB		**	**			**			**		
	NT		**	**			**			**		**
	EM		**				*			**		
	EB		**				*		**	**		
	ET	**	**	**			**		**	**		**
PR18 x VARDAN	NM		**	**			**		**	**		**
	NB	*		**			**			**		**
	NT	*	**	**			**			**		**
	EM	*	**	**			**			**		**
	EB		**	**			*		**	**		**
	ET	**	**	**			**		**	**		**
PR18 x BR40	NM		**	**		**	**		**	**	*	**
	NB		**	**			**			**		*
	NT	**	**	**			**			**		
	EM	**	**	**	*		**			**	*	
	EB	*	**	**			**		**	**		
	ET	*	**	**			*		**	**		**
RH843 x RH851	NM		**	**			**		**	**		**
	NB		**	**			**			**		**
	NT		**	**						**	**	**
	EM	**	**	**						**	**	**
	EB	**	**	**					**	**	**	*
	ET		**	**			**		**	**		**
RH843 x VARDAN	NM	**	**	**			**		**	**		
	NB	**	**	**			**			**		*
	NT	**	**	**			**			**		*
	EM		**	**			**			**		**
	EB		**	**			**		**	**	**	**
	ET	**	**	**			**		**	**	**	
RH843 x BR40	NM		**	*			**			**	*	**
	NB		**	**			**			**		
	NT	*	**	**			*			**		
	EM		**	**			**		**	**	*	**
	EB		**	**			*		**	**		**

	ET	**	<u>**</u>	<u>**</u>			<u>**</u>		**	<u>**</u>	<u>**</u>	<u>**</u>
RH851 x VARDAN	NM	*	<u>**</u>	<u>**</u>			<u>**</u>			**		<u>**</u>
	NB	**	<u>**</u>	<u>**</u>			<u>**</u>			<u>**</u>		<u>**</u>
	NT	**	<u>**</u>	<u>**</u>	*		<u>**</u>			<u>**</u>		<u>**</u>
	EM	**	<u>**</u>	<u>**</u>					**	<u>**</u>		
	EB	**	<u>**</u>	<u>**</u>			<u>*</u>		**	<u>**</u>	<u>**</u>	
	ET	**	<u>**</u>	<u>**</u>			<u>**</u>		**	<u>**</u>		<u>**</u>
RH851 x BR40	NM		**	<u>**</u>			<u>**</u>			**	*	<u>**</u>
	NB		**	<u>**</u>			<u>**</u>			<u>**</u>		<u>**</u>
	NT	**	<u>**</u>	<u>**</u>	*		<u>**</u>			<u>**</u>		<u>**</u>
	EM	<u>**</u>	**	**			**		**	<u>**</u>	*	<u>**</u>
	EB	<u>**</u>	**	**			<u>*</u>		**	<u>**</u>		<u>**</u>
	ET		<u>**</u>	<u>**</u>			<u>**</u>		**	<u>**</u>	<u>**</u>	<u>**</u>
VARDAN x BR40	NM		**	**		*	**		<u>**</u>	**		
	NB		**	<u>**</u>						**		<u>*</u>
	NT		<u>**</u>	<u>**</u>						<u>**</u>		<u>*</u>
	EM	**	<u>**</u>				<u>**</u>			<u>**</u>		<u>**</u>
	EB	**	<u>**</u>	<u>**</u>			<u>**</u>		**	<u>**</u>		<u>**</u>
	ET	**	<u>**</u>	<u>**</u>			<u>**</u>		**	<u>**</u>		<u>**</u>

*, ** Significant at 5 and 1% probability levels, respectively (<u>*</u> , <u>**</u> for negative).

EM is Heterosis over mid parent in East-West sowing direction, EB is Heterosis over better parent in East-West sowing direction, ET is Heterosis over best parent in East-West sowing direction, NM is Heterosis over mid parent in North-South sowing direction, NB is Heterosis over better parent in North-South sowing direction and NS is Heterosis over best parent in North-South sowing direction.

CHARACTERS: 1. Days to 50% flowering, 2. Primary branches/plant, 3. Secondary branches/ plant, 4. Plant height (cm), 5. Number of siliquae/ plant, 6. Number of Seeds/siliqua, 7. Days to maturity, 8. Harvest index, 9. 1000-Seed weight (g), 10. Seed yield/plant (g) and 11. Oil content (%)

Combining ability and stability study for yield and oil in Indian mustard in Alfisols of Jharkhand

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Abstract

Studies on combining ability, stability and G x E interaction were carried out at three dates of sowing in North-South sowing direction and three dates of sowing in East-West sowing direction on Indian mustard (*Brassica juncea*) for grain yield and yield attributes along with one quality character i.e. oil content in percent in 36 single cross hybrids developed using 9 x 9 diallel set (excluding reciprocals), which showed both additive and non-additive gene effects were important. The change in sowing direction showed selective sensitivity of gca and sca of yield and yield traits. RW873 was the best general combiner for days to 50% flowering, plant height, days to maturity and harvest index in North-South and East-West sowing directions. None of the crosses showed high sca for both North-South and East-West sowing directions for all traits. The crosses selected for seed yield / plant (RW29-6-3 x Vardan and PR 18 x BR40) and for oil content in *per cent* (RW873 x Vardan, Kranti x BR40 and RH843 x BR40) showed high desirable sca effects in both sowing directions. PR830 for North-South and RH851 for East-West sowing were stable for ten characters. The parents RW873, RW29-6-3, PR18 and BR40 were promising for North-South and East-West sowing directions. The crosses, Kranti x PR18 was stable for eleven characters for East-West sowing direction and stable for seven characters in North-South sowing direction. RW29-6-3 x RH851 was the stable for ten characters in North-South sowing direction and stable for eight characters in East-West sowing direction. The cross RW29-6-3 x RH843 was promising for North-South and East-West sowing directions.

Key words: Mustard, combining ability, gca, sca, environment, stability, sowing direction (North-South and East-West).

Introduction

Indian mustard having high yield potential is highly priced oilseed crop and is cultivated either sole or as inter-crop under irrigated or rainfed condition. The knowledge of gene action and combining ability helps in identifying the best combiners, which may be hybridized either to exploit heterosis or to accumulate genes through selection and in unerstanding the characters to choose the proper selection method to be followed in breeding programmes. Combining ability analysis is utilized to assess the nicking ability of genotypes and helps in identifying parents, which are likely to be successful to get desirable segregants in a hybridization program. The nature of genetic variation present in the base population is known genetic evaluation through various genetic parameters. An understanding of the susceptibility of these genetic parameters to change in sowing directions may be of great importance to a breeder to initiate a successful breeding program. In the present study an effort has been made to find out the genetic components and stability of seed yield and its attributes to formulate effective breeding strategy to improve seed yield along with other traits in Indian mustard. A desirable hybrid should possess stability in performance besides high yield. The high yielding ability and response to environmental changes are the two independent attributes of a genotype and are governed by separate gene system [4, 5]. A stable phenotypic expression of a character is the result of interaction between its genotype and the environment in which it develops. In view of this, present investigation was undertaken to study the stability and combining ability effects, by evaluating the 36 single cross hybrids, developed using 9 x 9 diallel set over six dates of sowing in East-West and North-South sowing directions for yield, yield attributes and oil content in per cent in Indian mustard.

Materials and Methods

Nine parents (RW873, PR830, Kranti, RW29-6-3, PR18, RH843, RH851, Vardan and BR40 were involved in a diallel mating design (excluding reciprocals) as suggested by Griffing [6]. Forty-five genotypes were grown on three dates (E_1 and E_4 on 27th September, E_2 and E_5 on 4th October and E_3 and E_6 on 11th October 1997) at North-South (E_1, E_2 and E_3) and East-West (E_4, E_5 and E_6) sowing directions in complete randomized block design with two replications on each date during winter at Birsa Agricultural University experimental area, Ranchi. The area is located between 23°17" latitude and 85"19'E longitude and altitude is 625 meters above the mean sea level. The P^H of the soil being 5.9. Each genotype was planted in a single row of 2m length with a row to row and plant to plant spacing of 30 cm and 10 cm, respectively. Grain yield per plant (g), number of primary branches, number of secondary branches, number of siliquae per plant, number of seeds per siliqua, days to 50% flowering, days to maturity, 100 seed weight (g), harvest index, oil content in per cent were recorded on ten randomly selected competitive plants in each plot excluding border plants in each replication for all the genotypes in all six environments. Cultural practices as recommended for the area were followed. Data were analyzed as per Griffing in method II and model I to estimate combining ability effects and followed the model proposed by Eberthart and Russell [7] to estimate the stability as mean, regression coefficient (b_i) and mean squared deviation ($S^{-2}d_i$) for each genotypes in each dates of sowing.

Results and Discussion

(i) Combining ability studies

In the present investigation, the combining ability analysis revealed significant mean squares due to general combining ability (**gca**) were significant for all characters studies in all sowing directions, whereas the mean squares associated with specific combining ability (**sca**) were non-significant for primary and secondary branches / plant in North-South sowing and, plant height and days to maturity in East-West sowing direction, thus, indicating the importance of both additive as well as non-additive gene effects for these traits and presence of significant genotypes x sowing direction interactions Table 1. Pooled analysis of variance, it was observed that both **gca** and **sca** mean squares were significant for most of the characters. These results are in concurrence with investigations carried out by earlier researchers [1–3 and 8], whereas Kumar and Yadav [2] supported the present findings in different environments. Under these circumstances, for exploiting non-additive gene action and to improve these characters one has to resort to the breeding procedures, which lead to heterozygous end products such as recurrent selection and reciprocal recurrent selection. Sowing direction x **gca** interactions were significant for most of the characters. Sowing direction x **sca** interactions were significant for all characters, except, plant height. Therefore, the change in sowing direction showed selective sensitivity of **gca** and **sca.**

On the examination of **gca** effects and *per se* performance, it was revealed that none of the parental genotype has desirable **gca** and *per se* performance for all these traits. The parental genotype RW 873 was the best general combiner for days to 50 % flowering, plant height, days to maturity and harvest index in North-South and East-West sowing direction. Whereas it is good combiner for North-South sowing direction for days to 50% flowering, plant height, days to maturity, harvest index and oil content in per cent. RW873 is also good combiner for East-West sowing direction for days to 50% flowering, plant height, days to maturity, harvest index, 1000-seed weight and seed yield/ plant (table 1). None of crosses showed high **sca** in North-South and East-West directions for most of the characters. Among the crosses selected for 1000 seed weight (PR830 x Vardan), seed yield/Plant (RW29-6-3 x Vardan and PR18 x BR40) and oil content (RW873 x Vardan, Kranti x BR 49 and RH843 x BR40) were the best crosses having high desirable **sca** effects in both North-South and East-West owing directions.

(ii) Stability analysis:

PR830 was stable for number of primary and secondary branches / plant, plant height, number of siliquae / plant, number of seeds / siliqua, days to maturity, harvest index, 1000 seed weight, seed yield/plant and oil content (%) and most desirable for North-South sowing and RH851 was stable for days to 50% flowering, number of primary and secondary branches/plant, plant height, number of siliquae/plant, number of seeds/ siliqua, harvest index, 1000 seed weight, seed yield/plant and oil content (%) and most desirable in East-West sowing direction among the parents Table 2. RH851 was most stable among forty-five genotypes for oil content in East-West sowing direction. The parent Kranti was most stable for harvest index in North-South sowing direction. The parent Vardan showed stability for days to 50% flowering, number of primary branches/plant, number of siliquae/plant, number

of seeds/siliqua, days to maturity, seed yield/plant and oil content (%) in East-West sowing direction among the genotypes, whereas in North-South sowing only for seed yield / plant. The parents RW873, RW29-6-3, PR18 and BR40 were promising for North-South, East-West and both directions of sowing.
Among the crosses, Kranti x PR18 was stable for days to 50% flowering, number of primary and secondary branches/plant, plant height, number of siliquae/plant, number of seeds/siliqua, days to maturity, harvest index, 1000 seed weight, seed yield/plant and oil content (%) and most stable for harvest index for East-West sowing direction, and stable for number of primary and secondary branches/plant, number of siliquae/plant, number of seeds/siliqua, harvest index, 1000 seed weight and seed yield/plant in North-South and Both sowing directions. The cross RW29-6-3 x RH851 was the stable for days to 50% flowering, number of primary and secondary branches/ plant, number of siliquae/plant, number of seeds/siliqua, days to maturity, harvest index, 1000 seed weight, seed yield/plant and oil content in North-South sowing direction and stable for number of secondary branches/plant, number of siliquae/plant, number of seeds/siliqua, days to maturity, harvest index, 1000 seed weight, seed yield/ plant and oil content in East-West sowing direction and stable for number of secondary branches/plant, number of siliquae/plant, number of seeds/siliqua, days to maturity, harvest index, 1000 seed weight, seed yield/ plant and oil content (%) in both the sowing directions. The crosses RW873 x Vardan, PR830 x PR18, Kranti x RW29-6-3, Kranti x RH843, Kranti x Vardan, RW29-6-3 x RH851, RW29-6-3 x Vardan, PR18 x RH843, RH843 x BR40 and RH851 x Vardan were stable and promising for North-South sowing direction. The cross RW29-6-3 x RH843 was stable for days to 50% flowering, number of primary branches /plant, plant height, number of siliquae/ plant, number of seeds/siliqua, harvest index, 1000 seed weight, seed yield/plant and oil content (%) in East-West sowing direction and stable for only four characters in North-South sowing direction. The crosses RW873 x Kranti, RW873 x RH851, RW873 x Vardan, PR830 x PR18, PR830 x Vardan, PR830 x RW29-6-3, Kranti x RH843, Kranti x RW29-6-3, Kranti x RH843, Kranti x RH851, Kranti x Vardan, RW29-6-3 x Vardan, PR18 x RH843, PR18 x Vardan and RH843 x BR40 were stable and promising for East-West sowing direction.

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Table 1. Combining ability in Indian mustard for different traits in North-South and East-West sowing directions.

Crosses		Characters										
		1	2	3	4	5	6	7	8	9	10	11
RW873	NS	**			**	**		**	**			**
	EW	**	*		**			*	**	*	**	
RW873 x	NS				*			*				*
PR830	EW	**							**			**
RW873 x	NS							**			**	
KRANTI	EW											
RW873 x	NS	**						**				
RW29-6-3	EW					**	*				**	
RW873 x	NS											**
PR18	EW				*		**	*	**	**	**	
RW873 x	NS		*		*					*		**
RH843	EW						*			*		*
RW873 x	NS	*				*		**				*
RH851	EW											
RW873 x	NS											**
VARDAN	EW											**
RW873 x	NS	**	**	*	**							
BR40	EW	**	*	*	**				**			**
PR830	NS	**										
	EW											
PR830 x	NS			*	*	*			**	**	**	
KRANTI	EW											**
PR830 x	NS				*		*		**			
RW29-6-3	EW								**			**
PR830 x	NS					**						*
PR18	EW											
PR830 x	NS								**			**
RH843	EW		*			*					*	**
PR830 x	NS		**	**		**					**	**
RH851	EW											**
PR830 x	NS	**		*		*	*	*	*	**		
VARDAN	EW						**			**		**
PR830 x	NS				*		**		**			
BR40	EW							*				**
KRANTI	NS									**	*	
	EW						*				**	**
KRANTI x	NS											*
RW29-6-3	EW				*		**			*		
KRANTI x	NS	*					**					**
PR18	EW				*							
KRANTI x	NS	*						*				**
RH843	EW					*	*				*	
KRANTI x	NS											
RH851	EW							*		*		**
KRANTI x	NS	**	**			*						**
VARDAN	EW							**				
KRANTI x	NS								**	**	**	**
BR40	EW				*		**		**			**
RW29-6-3	NS	**	*	**								**
	EW						*	**				**
RW29-6-3	NS								**			
x PR18	EW										**	**
RW29-6-3	NS			*		**					**	**
x RH843	EW					*					**	*
RW29-6-3	NS				**				*			*
x RH851	EW	*							*			
RW29-6-3 x	NS				**					**	*	
VARDAN	EW						**				**	*
RW29-6-3	NS	**			**	*					*	
x BR40	EW	*			*							
PR18	NS			*	*							**
	EW	**			*							*
PR18 x	NS		**	*	**	**			**			**
RH843	EW		*									
PR18 x	NS										*	
RH851	EW						*		*			*
PR18 x	NS			*		*						**
VARDAN	EW							*				**
PR18 x	NS					**					**	**
BR40	EW		**	**		**	**		**		**	

		1	2	3	4	5	6	7	8	9	10	11
RH843	NS		*		**	*			*			**
	EW		**	**	**	**				*	**	
RH843 x RH851	NS				**							**
	EW			*		**		**				
RH843 x VARDAN	NS		**									
	EW			**		*					**	**
RH843 x BR40	NS											**
	EW		**		*							*
RH851	NS	**						*				**
	EW	**							*			
RH851 x VARDAN	NS											*
	EW			*					*			**
RH851 x BR40	NS											
	EW	**		**	*		**	*	*			
VARDAN	NS			**							*	*
	EW	*			*		**	**				
VARDAN x BR40	NS	*		**		**		*				
	EW						*					**
BR40	NS	*							**		**	
	EW				**	*				**		*

*, ** Significant at 5 and 1% probability levels, respectively (*, ** for negative). EW = East-West sowing direction and NS = North-South sowing direction.

CHARACTERS: 1.Days to 50% flowering, 2.Primary branches/plant, 3.Secondary branches/plant, 4.Plant height (cm), 5.Number of siliquae/plant, 6.Number of Seeds/siliqua, 7.Days to maturity, 8.Harvest index, 9.1000-Seed weight (g), 10.Seed yield/plant (g) and 11.Oil content (%).

Table 2. Stability in Indian mustard for different characters in North-South and East-West sowing directions.

Crosses		Characters										
		1	2	3	4	5	6	7	8	9	10	11
RW873	NS		*	*		*	*	*	*	*		
	EW		*	*		*	*			*		
RW873 X PR830	NS		*			*	*	*		*	*	
	EW		*	*		*	*			*		
RW873 X KRANTI	NS		*	*	*				*	*		*
	EW	*	*	*	*		*	*		*	*	
RW873 X RW29-6-3	NS		*		*		*			*	*	**
	EW			*	*		*	*		*		*
RW873 X PR18	NS		*				*	*	*			*
	EW			*	**	*						*
RW873 X RH843	NS		*				*		*			
	EW	*		*	*	*		*				*
RW873 X RH851	NS	*	*		*		*		*	*		*
	EW	*	*	*	*			*	*	*	*	*
RW873 X VARDAN	NS	*			*	*	*	*	*	*	*	
	EW	*		*		*	*	*	*	*	*	*
RW873 X BR40	NS				**	*				*		*
	EW			*					*	*	*	*
PR830	NS		*	*	*	*	*	*	*	*	*	*
	EW		*	*	*	*	*			*	*	
PR830 X KRANTI	NS	*	*				*	*				
	EW	*	*	*	*			*			*	*
PR830 X RW29-6-3	NS			*		*		*			*	
	EW	*	*	*	*			*			**	
PR830 X PR18	NS	*	**	**			*	*	*	*	*	*
	EW		*	*		*	*		*	*	*	*
PR830 X RH843	NS		*	*		*	*	*				
	EW						*	*	*	*		
PR830 X RH851	NS						*		*	*		
	EW	*		*		*	*		*	*	*	
PR830 X VARDAN	NS		*	*	*				*		*	*
	EW		*	*	*	*		**	*	*	*	
PR830 X BR40	NS	*	*			*					*	
	EW		*	*		*	*	*	*	*	*	*
KRANTI	NS	*				*	*	*	*	**		*

	EW	*	*	*	*	*	*	*	*		*	
KRANTI X	NS		*	*	*		*		*	*	**	*
RW29-6-3	EW		*	*	*	*	*		*	*	*	*
KRANTI X	NS		*	*		*	*		*	*	*	
PR18	EW	*	*	*	*	*	*	*	*	**	*	*
KRANTI X	NS		*	*		**	*		*	*	*	*
RH843	EW	*	**	*			*	*	*	*	*	
KRANTI X	NS	*	*				*		*	*		
RH851	EW		*	*	*	*	*		*	*	*	*
KRANTI X	NS				*		*		*	*	*	*
VARDAN	EW	*	*	*	*				*	*	*	*
KRANTI X	NS		*	*		*	*				*	
BR40	EW	*	*	*						*		*
RW29-6-3	NS	*		*	*		*	*	*			
	EW	*	*	*	*			*			*	
RW29-6-3	NS		*				*	*			*	*
X PR18	EW			*	*		*	*		*	*	
RW29-6-3	NS		*				*		*	*		
X RH843	EW	*	*		*	*	*		*	*	*	*
RW29-6-3	NS	*	*	*		*	*	*	*	*	*	*
X RH851	EW			*		*	*	*	*	*	*	*
RW29-6-3 X	NS	*	*	*			*	*	*		*	*
VARDAN	EW	*	*	*	*	**		*	*	*		*
RW29-6-3	NS		*				*		*	*	*	*
X BR40	EW			*	*		**	*			*	*
PR18	NS	*	*	*		*	*	*	*	*		*
	EW	*		*		*	*	*		*	*	*
PR18 X	NS	*	*		*		*	*	*	*	*	*
RH843	EW	*		*	*	*		*	*	*	*	*
PR18 X	NS		*				*	*		*	*	
RH851	EW		*	*	*	*	*			*	*	*
PR18 X	NS	*	*		*		*	*	*			
VARDAN	EW	*	*	*		*	*	*	*	*	*	
PR18 X	NS			*			*					
BR40	EW	*			*							*
RH843	NS						*			*		
	EW	**		**		*				*	*	*
RH843 X	NS		*				**	**			*	
RH851	EW	*					**	*	*	*		*
RH843 X	NS	**			*		*	*		*	*	
VARDAN	EW	*		*	*		*		*	*		
RH843 X	NS	*	*		*	*	*	*	**			*
BR40	EW	*	*	*		*	*		*	*	*	
RH851	NS		*		*		*	*	*	*	*	
	EW	*	*	*	*	*	*		*	*	*	**
RH851 X	NS	*		*	*	*	*	*	*	*		*
VARDAN	EW		*	*	*		*			*	*	
RH851 X	NS		*	*		*	*	*		*	*	
BR40	EW		*		*				**		*	*
VARDAN	NS										*	
	EW	*	*			*	*	*			*	*
VARDAN X	NS		*		*				*		*	
BR40	EW			*	*	*					*	
BR40	NS	*	*	*		*	*	*	*			
	EW	*		*	*	*					*	*

*, ** Stable and most stable for character, respectively. EW = East-West sowing direction and NS = North-South sowing direction.

CHARACTERS: 1.Days to 50% flowering, 2.Primary branches/plant, 3.Secondary branches/ plant, 4.Plant height (cm), 5.Number of siliquae/ plant, 6.Number of Seeds/siliqua, 7.Days to maturity, 8.Harvest index, 9.1000-Seed weight (g) 10.Seed yield/plant (g) and 11. Oil content (%).

Screening of *Raphanus sativus* L. varieties for tolerance to aluminium toxicity.

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Abstract

Roots are more directly confronted with toxic metals in the environment. Aluminium being one of the most abundant metal in the earth's crust is detrimental to the plants in acidic soil limiting its growth and productivity. The problem of metal toxicity is more in developing countries like India. Hence this cruciferous root crop was chosen for study. The results revealed both the varieties(P.C.L. and M.E.W.) to be tolerant to this metal however P.C.L. is more than M.E.W.

Key words: Aluminium toxicity, radish, seed germination, Pusa Chetki Long(P.C.L.), Minu Early White (M.E.W.)

Introduction

The problem of metal intoxication and metallic pollution of environment is universal and the situation is more so in the developing countries like India. Aluminum (Al) is the most, abundant metal, comprising about 7% of its mass. Al toxicity is the major factor limiting crop productivity on acid soils, which comprise up to 40% of world's arable land. According to Foy (1984) Al toxicity is manifested in many ways such as drought stress, oxygen deficiency, water logging, high bulk density and disturbance in mineral nutrition in many plants.

Roots are more directly confronted with toxic metals in the environment than shoot except in case of aerial metal deposition. The estimation of metal tolerance by the root elongation test is based on the observation that toxic concentrations of many metals inhibit root growth (Woolhouse, 1983). The root elongation test has been widely used to quantify metal tolerance for several metals (Simon and Lefebvre, 1977).

Thus the present investigation was undertaken to examine Al tolerance in radish varieties, which is a root crop too.

Materials and Methods

The most easily recognized symptom of Al toxicity is the inhibition of root growth and this has become a widely accepted measure of Al stress in plants (Emmanuel Delhaize et.al. 1995). Certified seeds of two varieties of radish (*Raphanus sativus* L.) Pusa chetki long (P.C.L) and Minu Early white (M.E.W.) were obtained from green seed centre. Seeds were surface sterilized with 1% sodium hypochloride for 2 minutes. Petri plates were also sterilized and were lined with filter paper at bottom. Thirty healthy seeds of each variety were placed in petri plates containing 15$cm.^3$ each of water,10ppm, 50ppm and 100ppm of solution. They were incubated in a

B.O.D. incubator at 26 ± 2^0C in dark and investigations were carried at different stages of germination from 24 hr to 120 hr.

Metals are added to the hydroponic solution mostly as sulphates (Wilkins, 1975; Aniol; 1984). Solution of aluminium sulphate was prepared and taken at different concentration. Emergence of radical was taken as criterion for germination. Germination percentage, seedling growth, moisture percentage and Tolerance Index (T.I.) was calculated, following the method of Woolhouse (1983). The use of T.I. allows a perception of the coarse pattern of interspecific and intraspecific variations in metal tolerance. The qualitative determination of Al tolerance was investigated following the method of Rincon and Gonzales (1992) and Ownby (1993).

Result and Discussion

In the present investigation first symptom in the germinating seeds observed was change in colour of root tip to violet and of cotyledonary leaves from green to yellow with intensity corresponding to concentration from 10ppm to 100ppm. It was also found that the growth rate of roots and shoot are inhibited by Al in a concentration dependent manner (Table-II). At 10ppm less than 20% inhibition occurred and greater than 60% inhibition occurred at or above 50ppm concentration (Table-I) T.I. of the more tolerant variety P.C.L. ranged from 0.98 to 0.58 respectively at 10ppm and 100ppm and that of M.E.W. from 0.76 to 0.38 for root. The inhibition of root growth has also been reported by some workers (Kochian; 1995 and Elison et.al;1998) in wheat and other plants.

On staining with hematoxylin the roots appeared bluish purple in colour (Plate-I). Stain intensity increased in the less tolerant (M.E.W.) as compared to the more tolerant (P.C.L.) from lower to higher concentration of Al. According to some workers the pattern of hematoxylin staining depends upon differential Al binding to hematoxylin and reacting Al might be fixed in roots issue as aluminium phosphate. Polle et al. (1978) described the difference in hematoxylin staining with Al stressed roots in Al sensitive and Al-tolerant ones (Rincon and Gonzales, 1992).

In the present investigation decrease in moisture percentage was recorded in M.E.W. during 24hr. and 120hr. of seed germination, water deficit causes dehydration of protoplasm (Levitt, 1956) which results in loss of turgor. This reduction in moisture is obvious effect of water stress in almost all plant species

The data indicates the ability of both the varieties of radish to germinate and grow under toxic effects of aluminium. Al caused significant decrease in root growth in the variety M.E.W. The qualitative determination of Al tolerance might be observed with variety M.E.W. than in P.C.L.

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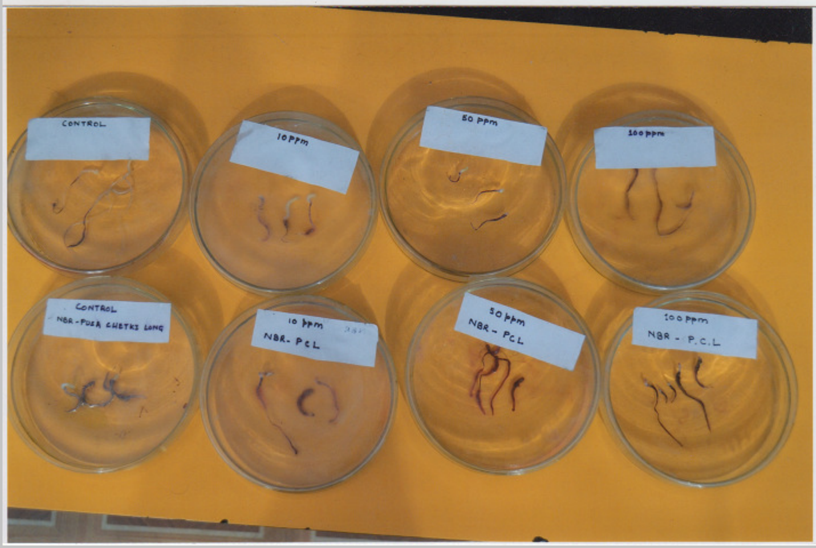

Plate. - I

Table – I Effect of Al on Germination percentage of P.C.L. and M.E.W.

P.C.L.						M.E.W.					
Treatment	**24 hr**	**48 hr**	**72 hr**	**96 hr**	**120 hr**	**Treatment**	**24 hr**	**48 hr**	**72 hr**	**96 hr**	**120 hr**
Control	90	100	100	100	100	Control	88	96	100	100	100
10ppm	81	89	90	94	100	10ppm	80	83	89	94	100
50ppm	73	78	84	91	97	50ppm	70	74	77	86	95
100ppm	65	74	83	89	94	100ppm	60	71	75	79	86

Table – II Effect of Al on Growth Parameters.

Parameters	**Treatments**	**P.C.L**	**Germination hrs.**				**M.E.W**				
		24h	**48h**	**72h**	**96h**	**120h**	**24h**	**48h**	**72h**	**96h**	**120h**
Root length	**Control**	-	1.2h cm	2.9 cm	5.1cm	6.0 cm	-	1.02cm	2.8 cm	5.0 cm	5.9 cm
(cm)	**10**	-	1.01 cm	2.6	4.4cm	5.1 cm	-	0.9 cm	2.3 cm	4.2 cm	5.0 cm
	50	-	0.98 cm	1.6	3.0cm	4.1 cm	-	0.7 cm	1.3 cm	2.5 cm	3.9 cm
	100	-	0.5 cm	1.1	1.9cm	2.8 cm	-	0.4 cm	1.0 cm	1.3 cm	1.6 cm
Shoot length	**Control**	-	1.5 cm	3.2	6.5cm	7.1 cm	-	1.4 cm	3.2 cm	6.5 cm	6.9 cm
(cm)	**10**	-	1.5 cm	2.9	4.1cm	5.0 cm	-	1.2 cm	2.3 cm	4.0 cm	4.8 cm
	50	-	0.9 cm	1.4	2.3cm	2.9 cm	-	0.8 cm	1.3 cm	2.3 cm	2.6 cm
	100	-	0.6 cm	0.9	1.2cm	1.8 cm	-	0.5 cm	0.9 cm	1.1 cm	1.4 cm

CRUCIFERAE NEWSLETTER Nr. 32

Instructions to the authors – 2012

<u>Deadline for contribution submission:</u> **December 1st 2012**

The current issue of the Cruciferae Newsletter (vol. 32) will be published online at the beginning of year 2013 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
Authors (year). Article title. Journal (use abbreviation if known). Vol: page-page.

Table 1. Title

Figure 1. Title