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Acknowledgements

The current issue of the Cruciferae Newsletter (vol. 32) is published online from the Brassica website (http://www.brassica.info/info/publications/cruciferae-newsletter.php). We apologize for being so late to publish this issue. The present issue contains 9 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).

The editing group,

Dr. Nathalie NESI, Dr. Anne-Marie CHEVRE,

Dr. Maria MANZANARES-DAULEUX

Contact:

UMR 1349 INRA-Agrocampus Ouest-Univ. Rennes1

Institute for Genetics, Environment and Plant Protection

BP 35327, 35653 Le Rheu cedex, France

http://www6.rennes.inra.fr/igepp_eng/

email: cruciferaenewsletter@rennes.inra.fr

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Development of *Brassica rapa* var yellow sarson line with filled terminal sinks

Ram Bhajan, Usha Pant, A.K. Singh and Sameer Chaturvedi

Department of Genetics & Plant Breeding, College of Agriculture,
G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India
Corresponding author: rbhajan@rediffmail.com

Abstract
Terminal unfruitfulness of sinks, an inherent defect, in yellow sarson has been corrected by crossing yellow sarson line MYSL-221 (with large barren sinks) with toria variety Rajendra sarson-1 (with smaller barren sinks). Following pedigree method of breeding, an improved line PYS 2008-5 has been developed. The new line is self compatible and self pollinated line having bilocular siliqua with upright bearing and filled sink apexes. It has shown >10% increase in seed yield over check variety PYS-1. This may serve a useful genetic resource for improvement of yellow sarson.

Key words: *Brassica rapa* var yellow sarson, unfilled sinks, terminal unfruitfulness

Introduction
Of the *Brassica rapa* L. ecotypes, *toria* is cross pollinated, yellow *sarson* is self pollinated and brown *sarson* includes both self (tora type) and cross (lotni type) pollinated forms. Presence of variable degree of self incompatibility and temporal isolation imposed by changes in flowering and maturity have restricted and narrowed down the variation with in each of the sub species (Rajan, 1958). Studies have shown that their desirable characteristics can be recombined.
The genotypes in the crops are morphologically determinate but the growth of the racemes is indeterminate. Flowers on racemes open acropetally with one or two flowers opening each day. Thus, flowering is not synchronous both within and between racemes on the same plant (Chauhan and Bhargava, 1984). Almost all available varieties/germplasm lines in these crops show terminal unfruitfulness of sinks, which is obviously an inherent defect. There exists considerable variation in the length of barren sinks in different genotypes. In general, toria plants exhibit lesser unfilled sinks while yellow sarson genotypes show larger unfruitfulness of sinks which is relatively more in tetralocular types than in bilocular types. Length of unfilled sinks also varies considerably in different environments. Stress during flowering-cum-pod filling stage increases unfruitfulness.

Material and Methods
Yellow sarson line MYSL-221 was crossed as seed parent with Rajendra Sarson-1 of toria. MYSL-221 is a self

compatible and self pollinated line with large unfilled terminal sinks and multilocular upright bearing while Rajendra Sarson-1 is a self incompatible and cross pollinated variety having smaller unfilled sinks and bilocular upright siliqua bearing. Pedigree method of breeding was followed to developed improved line.

Results and Discussion

To overcome the problem of terminal unfruitfulness of sinks in yellow sarson, wide hybridization between selected yellow sarson and toria lines was followed. The segregating generations were advanced following pedigree method of breeding with selection for self compatible types combining fertile sink apexes and agronomic features of yellow sarson. An advanced line, PYS 2008-5, derived from this cross has fully fertile terminal sinks (Table-1, Fig.-1). In this line only 2-3 terminal buds on sink apexes fail to set fertile siliquae which later gives appearance of fully filled terminal sinks from the top. The new line has bilocular siliquae with upright siliqua alignment. In multilocation State Varietal Trials, PYS-2008-5 showed >10% improvement in seed yield over check variety PYS-1 (Table 2). Thus the new line is agronomically superior and as such appears to be a good genetic resource for yellow sarson improvement.

Existence of genetic variation and the advancement made in improving this trait indicate the possibility of genetic up-gradation of yellow sarson genotypes using this line in hybridizations.

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Table 1. Relative variation in filled/unfilled sinks and yield related characters of PYS 2008-5 and some popular varieties of yellow sarson at Pantnagar

Characters	PYS-2008-5	B-9	Ragini	YSH-401	Pitambari	PPS-1
Days to maturity	110 ± 1.20	100 ± 1.11	118 ± 2.24	114 ± 1.28	115 ± 1.90	110 ± 1.97
Plant height (cm)	120.14 ± 3.72	103.6 ± 1.48	108.60 ± 4.50	114.80 ± 1.91	123.0 ± 3.81	109.60 ± 5.11
Length of main raceme (cm)	48.19 ± 2.03	50.20 ± 1.47	48.20 ± 2.01	55.84 ± 3.29	51.66 ± 1.17	41.17 ± 1.12
Primary branches/plant	10.40 ± 0.57	9.40 ± 1.15	9.80 ± 0.65	9.60 ± 0.57	11.20 ± 0.65	14.20 ± 0.65
Siliquae on main raceme	39.60 ± 1.35	32.60 ± 2.08	23.00 ± 3.12	29.00 ± 1.32	37.60 ± 1.04	36.20 ± 1.34
Seeds/siliqua	22.70 ± 0.89	21.20 ± 1.19	39.80 ± 0.96	41.60 ± 1.04	37.40 ± 1.25	37.40 ± 1.04
Length of unfilled sink (cm)	0.50 ± 0.02	2.80 ± 0.17	5.10 ± 0.22	7.50 ± 0.13	6.10 ± 0.23	2.40 ± 0.21

Table 2. Performance of PYS-2008-5 in multilocation SVT trials over years

Genotypes	Seed yield (kg/ha)			Mean	% increase over best check, PYS-1
	2009-10	2010-11	2011-12		
PYS-2008-5	1531 (2)	1469 (2)	1291 (3)	1410 (7)	11.42
PYS-1 (Check)	1472 (2)	1210 (2)	1192 (3)	1277 (7)	-

Note: Figures with in parenthesis indicate number of test environments

Fig 1. Yellow sarson varieties with unfilled sinks apexes and filled sink apex of PYS-2008-5 (extreme right)

In vitro plant regeneration from anthers of Indian mustard

Ripu D. Kaur*[1], Ram C. Yadav[1], Neelam R. Yadav[1],Asha Rani[1] ,Prince Saini[1] and D. Singh[2]

[1] Department of Molecular Biology and Biotechnology
[2] Department of Genetics and Plant Breeding
CCS Haryana Agricultural University, Hisar- 125004, Haryana, India
* Corresponding author: r.ripudaman09@gmail.com

Abstract
The present study was carried out to observe androgenic responses in two Indian mustard genotypes viz. RH 749 and RH 919. B5 modified media combinations and MS modified medium were tried for anther culture. The collected floral buds were given cold pretreatment for 4-5 days, and after culturing, the anthers were given a heat shock treatment at 32℃ for 2 days. Out of both genotypes of *Brassica juncea*, RH 749 showed better androgenic response than RH 919. Highest per cent callusing anthers were observed on B5 medium supplemented with 100 g/L sucrose + 30 mg/L glutathione + 100 mg/L serine + 0.05 mg/L BAP + 0.5 mg/L NAA + 20 mg/L silver nitrate i.e. (50.01± 2.80) in genotype RH 749. The present study also showed that silver nitrate enhanced androgenic response in Indian mustard.

Key words: Brassica juncea, anther culture, silver nitrate, embryogenic anthers

Introduction
Indian mustard is an important oilseed crop of Brassicacaece family. Due to its wide usage as oil, forage, condiments and for medicinal purposes, the crop holds a great economic importance. The crop is widely grown in India and its demand is rising continuously with the increase in population. The productivity of *B. juncea* is adversely affected by biotic and abiotic stresses such as insect, pest, bacterial & fungal diseases, drought & cold. However, estimated demand for vegetable oils is likely to be around 34 million tones by 2020 A.D. of which 14 million tones is to be provided by Rapeseed-mustard (Anonymous, 2009). Efforts are being made to produce varieties resistant to biotic and abiotic stresses with better yield and enhanced nutritional qualities. Anther culture serves as an important tool for advancement in plant research and haploid production. Through this technique doubled haploids can be produced in less time as compared to the time taking repetitive self crossing conventional breeding methods. Double haploid technology is a fast method to create homozygous lines, which can be used to accelerate crop improvement programs (Ferrie and Caswell, 2011).

Materials and Methods
Immature floral buds collected from the field were refrigerated at 4°C for 4-5 days. The anthers were crushed in

acetocarmine stain and were checked for uninucleate or binucleate stages. Buds were washed with distilled water containing 2-3 drops of Tween 20 and were surface sterilized with 70% ethanol for 1 min. followed by washing in sterilized distilled water 3-4 times. The sterilized immature buds were opened by making a cut with the help of forceps. The anthers were excised and cultured on petriplates containing different media combinations. They were given heat shock treatment by keeping the inoculated petriplates in incubator at 32^{o}C for 2 days and then shifting the cultures to culture room at 25±1^{o}C in dark. After a few weeks, anthers began to respond via callogenesis and embryogenesis. Emerging embryos were subcultured on B5 basal growth regulator free media. Anthers showing calluogenetic responses were subcultured on MS medium supplemented with 1 mg/L BAP and 0.3 mg/L 2, 4-D.

Results and Discussion

In present study, effect of silver nitrate higher could be clearly observed, as B5 medium supplemented with 20 mg/L silver nitrate (media F) yielded higher per cent callusing anthers, per cent morphogenic calli, per cent embryogenic anthers as compared to B5 medium supplemented with 20 mg/L silver nitrate (media E). Similar results were reported by Malik *et al.* (2001) and Prem *et al.* (2005). In Brassica species, least response was noted in B5 medium devoid of silver nitrate. However, no androgenic response was observed on medium C, medium D and medium E. Comparing both the genotypes, RH 749 was observed to be more responsive than RH 919. In present investigation, highest per cent callusing anthers were observed in genotype RH 749 i.e. 50.01±2.80 (%) on medium F followed by 41.92±1.24 (%) on medium E. Similar callus induction results were obtained by Burbulis *et al.* (2004). They reported 62.9%, 50% and 35.4% callogenesis in *Brassica napus* genotypes Trend, Landmark and Auksiai respectively. However, Sayem *et al.* (2010) studied three *Brassica* genotypes viz. BARI Sarisha-6, BARI Sarisha-8 and BARI Sarisha-11, they obtained maximum callus induction (23.47%) in genotype BARI Sarisha-8 followed by 20.80% in BARI Sarisha-11. They observed influence of genotype on callus induction pattern. Comparing studies conducted by Sayem *et al.* (2010) and Burbulis *et al.* (2004) on *B. napus*, it can be concluded that different genotypes of same species can respond differently to the same medium differing in their per cent calluogenic potential. In our study also genotypic responses were observed.

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Table 1. Per cent androgenic and embryogenic response on different media used for anther culture of Indian mustard

Media code	Medium used	Per cent androgenic response		Per cent embryogenic response	
		RH 749	RH 919	RH 749	RH 919
A	B5 + 100 g/L sucrose + 30 mg/L glutathione + 100 mg/L serine + 0.05 mg/L BAP + 0.5 mg/L NAA	18.44±3.15	4.96±1.96	0	0
B	MS + 100 g/L sucrose + 30 mg/L glutathione + 100 mg/L serine + 0.05 mg/L BAP + 0.5 mg/L NAA	0	0	0	0
C	B5 + 100 g/L sucrose + 30 mg/L glutathione + 100 mg/L serine + 800 mg/L glutamine 0.05 mg/L BAP + 0.5 mg/L NAA	0	0	0	0
D	B5 + 130 g/L sucrose + 30 mg/L glutathione + 100 mg/L serine + 800 mg/L glutamine + 0.05 mg/L BAP + 0.5 mg/L NAA	0	0	0	0
E	B5 + 100 g/L sucrose + 30 mg/L glutathione + 100 mg/L serine + 0.05 mg/L BAP + 0.5 mg/L NAA + 10 mg/L silver nitrate	38.49±0.75	23.61±1.49	32.57±1.13	24.52±1.33
F	B5 + 100 g/L sucrose + 30 mg/L glutathione + 100 mg/L serine + 0.05 mg/L BAP + 0.5 mg/L NAA + 20 mg/L silver nitrate	50.01±2.80	41.92±1.24	36.02±0.61	34.01±1.08

Cytogenetic response of 24-epibrassinolide in *Brassica oleracea* var. botrytis under temperature stress

Saroj Kumar Pradhan* and Raghbir Chand Gupta

Department of Botany, Punjabi University, Patiala 147002 India
* Corresponding author: pradhan_sarojkumar@yahoo.com

Abstract

The effect of EBR on the germination and mitotic index in *Brassica oleracea var. botrytis* exposed to temperature stress was investigated. Seeds were treated with different concentrations of EBR or in combination with temperature 4 and 44℃ for pre-sowing treatment. EBR application shows increase in germination and mitotic activity under both low and high temperature stress. EBR mitigates the negative effects of temperature stress by increasing the final germination and mitotic activity

Keywords: Temperature stress, Brassica, Germination, Mitotic index, Epibrassinolide

Introduction

Brassica oleracea var. botrytis L. is one of the most important vegetable belonging to the family Brassicaceae. With the evolution of Indian cauliflower, it is now being grown during summer and rainy season also (Kumar et al. 2011). Brassinosteroids (BRs) are a new group of plant hormones with significant growth-promoting activity. BRs have been found in almost all the aerial parts of plants, pollen, flowers, shoots, vascular cambium, leaves, fruits, and seeds. BRs as plant hormones influence varied developmental processes such as seed germination, senescence, cell division, flowering, abscission, maturation and also confer resistance to plant against varies abiotic stresses(Syed Ali Fathima et al, 2011). Temperature is a major environmental factor that changes from season to season and plants being sessile respond to these changes by actively adjusting their biology to fit the subsequent temperature regime (Browse and Xin 2003). Temperature affects total germination in *Brassica* as they are mainly winter crops. In present study cytogenetic response of epibrassinolide and final germination in *Brassica oleracea var. botrytis* under temperature stress was investigated.

Materials and Methods

In present work, seeds of *Brassica oleracea var. botrytis* were procured from PAU, Ludhiana. The growth hormone was dissolved in the 0.05% ethanol and then distilled water was added to make the stock solution. Different concentrations of EBR were made from stock solution. Seeds were surface sterilized by 0.01% $HgCl^{-}_{2}$. Seed were soaked in constant volumes of DW and EBR (10^{-11}, 10^{-9}, 10^{-7}) for 5hrs alone or in combination

with temperature 4 and 44℃ for pre-sowing treatment. Uniform seeds from every treatment were sown in Petri dishes and placed in growth chamber in controlled conditions. Seeds were considered germinated when the radicals reached about 2-3 mm in length. The germination percentage of the seeds was calculated on 8th DAS. For cytogenetic analysis roots were fixed in 1:3 acetoalcohol for 24h and stored in 70% alcohol at 4℃. Roots were hydrolyzed in 1N HCL at 60° C for 30mins, stained with 2% acetocarmine. To determine the effect of EBR and temperature on mitotic index at least 1500 cells were scored.

Results and Discussion

In control seeds the germination was 80 percent while decrease in the final germination was observed in temperatures stress condition. Seeds soaked with EBR show enhanced germination at all concentrations as compared with untreated. In low temperature stress final germination was 72 percent while in high temperature stress it was 70 percent (Table 1). Kagale et al. 2007 observed the positive effect of BR on seed germination in *B.napus* under salt stress. EBR mitigates the negative effect of temperature stress by enhancing the final germination in both low and high temperature stress in *B.oleracea var botrytis*. Maximum germination was observed in EBR treated seeds at 10^{-7} M. On an overall EBR was most effective at 10^{-7} M concentration under both low and high temperature stress in increasing germination. Mitotic Index in control seeds was (5.98±0.657) while in low temperature stress it was (6.85±0.113) and in high temperature (9.00 ±0.234). EBR regulates the cell cycle at all concentrations by increasing the mitotic index. Maximum mitotic observed in EBR treatment alone was at 10^{-7} M (9.15±0.765). Under both low and high temperature stress EBR at all concentrations increases the mitotic index very effectively. Maximum mitotic index under low temperature stress was observed in EBR at 10^{-11} M (9.55±0.329), while in high temperature stress it was effective at 10^{-7} M (11.54±0.321) (Table 1). In present study EBR regulates the cell cycle very effectively which was confirmed by the previous report of Kartal et al. 2009 in barley seedlings. It also positively regulates under temperature stress in cauliflower seedlings. Present studies show the positive effect of EBR on seed germination and mitotic index under temperature stress.

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Table 1. Effect of 24-epibrassinolide on Final Germination and Mitotic Index in *Brassica oleracea var. botrytis* under temperature stress. Values are mean±SE

EBR (M)	Final Germination (%) ±SE			Mitotic Index (%)±SE		
	Brassica oleracea var. botrytis					
	Control	4℃	44℃	Control	4℃	44℃
0	80.00±0.00	72.00±3.33	70.00±1.66	5.98±0.657	6.85±0.113	9.00 ±0.234
10^{-11}	85.00±1.66	74.00±1.66	75.00±2.88	7.45±0.123	9.55±0.329	9.99 ±0.000
10^{-9}	86.66±0.00	80.00±0.00	81.00±1.66	8.55±0.342	8.85±0.167	10.56±0.045
10^{-7}	90.00±0.00	82.00±2.88	78.00±0.00	9.15±0.765	7.99±0.543	11.54±0.321

Intercropping spring-grown brassicas and legumes for forage production

Aleksandar Mikić[1], Branko Ćupina[2], Vojislav Mihailović[1], Ana Marjanović-Jeromela[1], Svetlana Antanasović[2], Đorđe Krstić[2], Snežana Katanski[1], Branko Milošević[1]

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

Introduction

Intercropping is one of the oldest way of cultivating crops (Hauggaard-Nielsen et al. 2011)and basically represents a concurrent growing at least two different species at the same place, comprising diverse possibilities, such as annual crops with each other, mixtures of perennial species or sowing annuals together with or into already established perennials. In Europe, West Asia and North Africa, intercropping annual legumes with cereals has been one of the most widely distributed ways of forage or grain production, where each component positively contributes to an intercrop performance in a different way (Bedoussac & Justes 2010).

However, the available literature on intercropping brassicas with legumes is rather scarce, although there are recently published results showing diverse benefits for a brassica component, where a legume component assists its brassica companion in uptaking less available nutrients much easier (Cortés-Mora et al. 2010).

The goal of this study was to assess the potential of intercropping various spring-sown brassicas with legumes for forage production.

Materials and Methods

A small-plot trial has been carried out in the trial years of 2011 and 2012 at the Experimental Field of the Institute of Field and Vegetable Crops at Rimski Šančevi in the vicinity of Novi Sad. It included six intercrops of spring-sown brassicas wit spring-sown annual legumes. In this case, two brassicas, rapeseed (*Brassica napus* L. var. *napus*) cv. Jovana and white mustard (*Sinapis alba* L.) cv. NS Gorica played the role of supporting crops for four legumes, namely pea (*Pisum sativum* L.) cv. Jantar, common vetch (*Vicia sativa* L.) cv. Perla, and grass pea (*Lathyrus sativus* L.) cv. Sitnica, acting as supported crops. All five cultivars, developed at the Institute of Field and Vegetable Crops, were also sown as sole crops.

In both trial years, all six intercrops and all five sole crops were sown in the first week of March, at a double reduced rate in the intercrops in comparison to those in the sole crops, that is, 20 viable seeds m^{-2} for rapeseed and white mustard, 50 viable seeds m^{-2} for pea and grass pea and 60 viable seeds m^{-2} for common vetch. The

sole crops of the brassica cultivars were cut in the stages of full budding and beginning of flowering, while the sole crops of the legume cultivars were cut when in full bloom. The intercrops were cut when either brassica or legume component reached its own optimum stage, what, in both trial years, happened rather concurrently.
Forage dry matter yield (t ha^{-1}) was determined in all five pure stands and their six intercrops, while for the latter the corresponding land equivalent ratio for forage dry matter yield (LER_{FDMY}) was calculated according to the following formula:

$LER_{FDMY} = B_{IC} / B_{SC} + L_{IC} / L_{SC}$,

where B_{IC} is the forage dry matter yield of a brassica component in an intercrop, B_{SC} is the forage dry matter yield of a brassica component in its sole crop, L_{IC} is the forage dry matter yield of a legume component in an intercrop and L_{SC} is the forage dry matter yield of a brassica component in its sole crop.
The study results were processed by analysis of variance (ANOVA) with the Least Significant Difference (LSD) test applied.

Results and Discussion

The two-year average forage dry matter yield in the sole crop of rapeseed (6.9 t ha^{-1}) was much higher than in the previous trial in the same agroecological conditions, with 3.0 t ha^{-1} (Krstić et al. 2012), while the two-year average forage dry matter yield in the sole crop of pea was also higher than in the preliminary results, with 8.2 t ha^{-1} (Mihailović et al. 2009). The highest two-year average individual contribution in the total forage dry matter yield among brassicas was in rapeseed (3.9 t ha^{-1}) when intercropped with common vetch, while the highest individual contribution in the total forage dry matter yield among legumes was in grass pea (6.2 t ha^{-1}) when intercropped with white mustard. The two-year average values of LER_{FDMY} ranged between 1.07 in the intercrop of rapeseed with grass pea and 1.25 in the intercrop of whit mustard with pea. Overall, the variation in the two-year average values of LER_{FDMY} of the spring-sown intercrops of brassicas with legumes was similar to the one in the spring-sown intercrops of legumes with each other, with a range from 1.04 in the intercrop of white lupin with grass pea and 1.44 in the intercrop of faba bean with grass pea 1.42 (Mikić et al. 2012), as well as much wider in comparison with the values of LER_{FDMY} in the mixtures of pea cultivars of different leaf type, with 1.11 (Ćupina et al. 2010).

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

Pure stand / Intercrop	Brassica forage dry matter yield	Legume forage dry matter yield	Total forage dry matter yield	LER_{FDMY}
Rapeseed	6.9	-	-	-
White mustard	4.2	-	-	-
Pea	-	8.4	-	-
Common vetch	-	7.6	-	-
Grass pea	-	8.8	-	-
Rapeseed + pea	3.7	4.9	8.6	1.12
Rapeseed + common vetch	3.9	4.2	8.1	1.12
Rapeseed + grass pea	3.1	5.5	8.6	1.07
White mustard + pea	2.5	5.5	8.0	1.25
White mustard + common vetch	2.7	4.2	6.9	1.20
White mustard + grass pea	1.8	6.2	8.0	1.13
$LSD_{0.05}$	0.4	0.8	0.8	0.09

Conclusions

Despite its preliminary character, the results of the trial with intercropping spring-sown brassicas with legumes show they have a great potential for forage production and thus deserve more attention. Most of the tested intercrops are notable for a balance between the single contribution of each component to the total forage dry matter yield, with grass pea as an exception due to its high competing ability when both intercropped or towards weeds. Among the future steps of this research are quality issues and underground aspects.

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Intercropping autumn-grown brassicas with legumes for forage production

Branko Ćupina[1], Aleksandar Mikić[2]*, Ana Marjanović-Jeromela[2], Đorđe Krstić[1], Svetlana Antanasović[1], Pero Erić[1], Sanja Vasiljević[2], Vojislav Mihailović[2]

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

Introduction

According to numerous definitions by various authors, intercropping may generally be considered a practice of growing of at least two different cultivated plant species at the same place and time and is surely one of the most ancient agricultural practices (Hauggaard-Nielsen et al. 2011). One of the most traditional ways of intercropping for forage production in temperate regions is the one that includes annual legumes and cereals (Bedoussac & Justes 2010).

On the other hand, little is known on intercropping brassicas with legumes, although certain recent results demonstrate multiple benefits for a brassica component, especially in terms of easier uptake of less available nutrients due to a positive influence of its legume companion (Cortés-Mora et al. 2010).

The aim of this study was to examine the potential of intercropping various autumn-sown brassicas with legumes for forage production.

Materials and Methods

A small-plot trial has been carried out in the trial years of 2010/2011 and 2011/2012 at the Experimental Field of the Institute of Field and Vegetable Crops at Rimski Šančevi in the vicinity of Novi Sad. It included eight intercrops of autumn-sown brassicas with autumn-sown annual legumes. Two brassicas, in this case, fodder kale (*Brassica oleracea* L. var. *viridis* L.) cv. Perast and rapeseed (*Brassica napus* L. var. *napus*) cv. Zorica played the role of supporting crops for four legumes, namely pea (*Pisum sativum* L.) cv. NS Krmni, common vetch (*Vicia sativa* L.) cv. NS Tisa, Hungarian vetch (*Vicia pannonica* Crantz) cv. Panonka and hairy vetch (*Vicia villosa* Roth) cv. NS Viloza, acting as supported crops. All six cultivars, developed at the Institute of Field and Vegetable Crops, were also sown as sole crops.

In both trial years, all eight intercrops and all six sole crops were sown in the last week of September, at a double reduced rate in the intercrops in comparison to those in the sole crops, that is, 25 viable seeds m^{-2} for fodder kale, 15 viable seeds m^{-2} for rapeseed, 60 viable seeds m^{-2} for pea and 75 viable seeds m^{-2} for common, Hungarian and hairy vetches. The sole crops of the brassica cultivars were cut in the stages of full budding and

beginning of flowering, while the sole crops of the legume cultivars were cut when in full bloom. The intercrops were cut when either brassica or legume component reached its own optimum stage, what, in both trial years, happened rather concurrently.

Forage dry matter yield (t ha^{-1}) was determined in all six pure stands and their eight intercrops, while for the latter the corresponding land equivalent ratio for forage dry matter yield (LER_{FDMY}) was calculated according to the following formula:

$LER_{FDMY} = B_{IC} / B_{SC} + L_{IC} / L_{SC}$,

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

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 a level of 0.05 in both two-year average forage dry matter yield in both intercrops and sole crops, as well as in the two-year average values of LER_{FDMY} (Table 1).

The two-year average forage dry matter yield in the sole crop of fodder kale (7.5 t ha^{-1}) was much higher than in the previous trial in the same agroecological conditions, with 4.1 t ha^{-1} (Ćupina et al. 2010), while the two-year average forage dry matter yield in the sole crop of pea was rather similar to the preliminary results, with 9.1 t ha^{-1} (Mihailović et al. 2009). The highest two-year average individual contribution in the total forage dry matter yield among brassicas was in fodder kale (4.5 t ha^{-1}) when intercropped with Hungarian vetch, while the highest individual contribution in the total forage dry matter yield among legumes was in hairy vetch (6.6 t ha^{-1}) when intercropped with rapeseed. The two-year average values of LER_{FDMY} ranged between 1.05 in the intercrop of fodder kale with common vetch and 1.14 in the intercrop of fodder kale with Hungarian vetch. Overall, the variation in the two-year average values of LER_{FDMY} of the autumn-sown intercrops of brassicas with legumes was narrower in comparison to the the autumn-sown intercrops of legumes with each other, with a range from 1.05 in the intercrop of faba bean with pea and 1.42 in the intercrop of faba bean with common vetch (Ćupina et al. 2011).

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

Pure stand / Intercrop	Brassica forage dry matter yield	Legume forage dry matter yield	Total forage dry matter yield	LER_{FDMY}
Fodder kale	7.5	-	-	-
Rapeseed	6.9	-	-	-
Pea	-	9.2	-	-
Common vetch	-	8.5	-	-
Hungarian vetch	-	6.5	-	-
Hairy vetch	-	9.6	-	-
Fodder kale + pea	4.0	4.8	8.8	1.06
Fodder kale + common vetch	4.2	4.2	8.4	1.05
Fodder kale + Hungarian vetch	4.5	3.5	8.0	1.14
Fodder kale + hairy vetch	3.2	6.1	9.3	1.06
Rapeseed + pea	3.7	5.2	8.9	1.10
Rapeseed + common vetch	3.8	4.5	8.3	1.08
Rapeseed + Hungarian vetch	4.1	3.3	7.4	1.10

Rapeseed + hairy vetch	2.8	6.6	9.4	1.09
$LSD_{0.05}$	0.5	0.9	0.8	0.03

Conclusions

The autumn-sown intercrops of brassicas with legumes have demonstrated a considerable potential for forage production. In the majority of the tested intercrops, there is a notable balance in the individual contribution of each component to the total forage dry matter yield. The only exception is hairy vetch, already well-known for its equally aggressive behaviour when intercropped or towards weeds.

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Potential of brown mustard (*Brassica juncea*) as a green manure crop

Vojislav Mihailović[1], Aleksandar Mikić[1], Branko Ćupina[2], Đorđe Krstić[2], Svetlana Antanasović[2], Maja Manojlović[2], Ranko Čabilovski[2], Ana Marjanović-Jeromela[1]

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

Introduction

Many crops belonging to the family *Brassicaceae* Burnett (syn. *Cruciferae* Juss.), widely referred to simply as *brassicas*, are cultivated mostly for their oil- and protein-rich seeds, such as rapeseed (*Brassica napus* L. var. *napus*) and white mustard (*Sinapis alba* L.), or for forage, such as fodder kale (*Brassica oleracea* L. var. *viridis* L.). Recently, it has been demonstrated that they may be used for green manure as well (Krstić et al. 2010), thus confirming their importance in environment-friendly cropping systems and providing modern agriculture with ecological services.

Brown mustard (*Brassica juncea* (L.) Czern.) is considered one of the significant oil crops, most notably in Indian subcontinent (Mahmood et al. 2005), with a number of desirable agronomic traits, such as prominent heat and drought tolerance or shattering resistance. Apart from this, brown mustard may be used as a forage crop for diverse temperate regions in Europe, such as the Balkan Peninsula (Ćupina et al. 2012).

The aim of this study was to examine the potential of brown mustard for the use as a green manure crop.

Materials and Methods

A small-plot trial has been carried out in the trial years of 2011 and 2012 at the Experimental Field of the Institute of Field and Vegetable Crops at Rimski Šančevi. It included eight experimental spring-sown brown mustard lines developed at the Experimental Field of the Institute of Field and Vegetable Crops, namely BM 01, BM 02, BM 03, BM 04, BM 05, BM 06, BM 07 and BM 08.

In both trial years, all eight lines were sown in the first week of March, with a plot size of 5 m^{-2}, at a seeding rate of 50 viable seeds m^{-2} and with three replicates, and were cut in the stages of full budding and beginning of flowering.

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

Table 1. Two-year average values of fresh aboveground biomass yield, dry aboveground biomass yield and aboveground biomass nitrogen yield in brown mustard lines at Rimski Šančevi for 2011 and 2012

Genotype	Fresh aboveground biomass yield (t ha^{-1})	Dry aboveground biomass yield (t ha^{-1})	Aboveground biomass nitrogen yield (kg ha^{-1})
BM 01	30.1	2.7	75
BM 02	31.7	2.8	79
BM 03	36.8	3.3	92
BM 04	54.0	4.9	135
BM 05	30.0	2.7	75
BM 06	50.6	4.6	127
BM 07	30.7	2.8	77
BM 08	52.7	4.7	132
Average	40.9	3.7	103
$LSD_{0.05}$	8.9	1.0	33
$LSD_{0.01}$	11.2	1.3	45

There were significant differences at both levels of 0.05 and 0.01 in all three monitored parameters of spring-sown lines of brown mustard (Table 1).

The lines BM 04 and BM 08 had the highest two-year average fresh aboveground biomass yield (54.0 t ha^{-1} and 52.7 t ha^{-1}), while the lines BM 05 and BM 01 had the lowest two-year average fresh aboveground biomass yield (30.0 t ha^{-1} and 30.1 t ha^{-1}). In comparison to the results of a trial with fodder kale genotypes in the same agroecological conditions, with an average of 51.2 t ha^{-1} (Ćupina et al. 2010), the tested brown mustard lines had lower aboveground fresh biomass yield.

The two-year average dry aboveground biomass yield ranged from 2.7 t ha^{-1} in BM 01 and BM 05 and 2.8 t ha^{-1} in BM 02 and BM 07, on one side, to 4.6 t ha^{-1} in BM 06, 4.7 t ha^{-1} in BM 08 and 4.9 t ha^{-1} in BM 04, on another side. This was lower than the two-year average dry aboveground biomass yield (5.1 t ha^{-1}) produced by autumn-sown rapeseed genotypes (Antanasović et al. 2012a).

The highest two-year average aboveground biomass nitrogen yield was in the lines BM 04 (135 kg ha^{-1}) and BM 08 (132 kg ha^{-1}), while the lowest two-year average aboveground biomass nitrogen yield was in the lines BM 01 and BM 05 (both 75 kg ha^{-1}). Overall, the tested spring-sown brown mustard lines had higher aboveground biomass nitrogen yield in comparison to the average by spring-sown rapeseed genotypes, with 80 kg ha^{-1}, also at Rimski Šančevi (Krstić et al. 2012), and exactly the same aboveground biomass nitrogen yield as lentil cultivated for green manure, with 80 kg ha^{-1}, in the same agroecological conditions (Antanasović et al. 2012b).

Conclusions

Spring-sown brown mustard lines showed a certain potential for the use as green manure, with high aboveground biomass nitrogen yields that may surpass 100 kg ha^{-1}, opening the possibility of developing the brown mustard cultivars specifically for green manure.

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Performance of moisture conservation and nutrient management practices on Ethiopian mustard and chickpea intercropping system

B. Lal*, K.S. Rana, Priyanka Gautam and Ekta Joshi

Division of Agronomy, Indian Agricultural Research Institute, New Delhi-12, India
Corresponding author: blalsgnr@gmail.com

Abstract
A field experiment was conducted during *Rabi* season (October- April) of 2008-09 and 2009-10 to study the moisture conservation and nutrient management in a mustard-chickpea intercropping system under rainfed conditions. Intercropping system of Ethiopian mustard and chickpea provided significantly higher growth, productivity and profitability under limited moisture condition.

Keywords: Intercropping, Ethiopian mustard, rainfed conditions, nutrient management

Introduction
Mustard and chickpea is a prominent intercropping system not only in the Indo-Gangetic plains of North India but in the entire Indian sub-continent on dry land conserved moisture conditions. Scientific approach of intercropping of these two crops increases the productivity per unit area per unit time under a situation where two crops are grown in certain proportion and row ratio. Ethiopian mustard is the most neglected *Brassica* digenomic species of U triangle in terms of crops improvement despite the fact that the species is an excellent repository of genes for tolerance to various biotic and abiotic stresses. The agronomic performances and the energetic balances confirmed that *B. carinata* adapted better and was more productive both in adverse conditions and under low cropping system when compared with *B. napus.* The potential of Ethiopian mustard has not explored much in India and there is, a need to cultivate this crop along with suitable cropping system, moisture conservation practices and nutrient management to obtain higher yield. The aim of this study was to assess the intercropping performance of Ethiopian mustard and chickpea under dry land conditions.

Materials and Methods
A field experiment was conducted during *Rabi* season (October- April) of 2008-09 and 2009-10 at research farm of Indian Agricultural Research Institute, New Delhi, to study the moisture conservation and nutrient management in a mustard-chickpea intercropping system under rainfed conditions. The experiment was laid out in split plot design with three treatment factors comprising (i) Cropping system (Ethiopian mustard sole,

Chickpea sole, Ethiopian mustard+ Chickpea (1:4), (ii) Moisture conservation practices (control, FYM@ 5tha^{-1}+ Organic mulch + Kaolin 6% spray), and (iii) fertility levels (control, 30 kg P_2O_5 ha^{-1}, 30 kg P_2O_5 ha^{-1} + 15 kg S ha^{-1}, 60 kg P_2O_5 ha^{-1} and 60 kg P_2O_5 ha^{-1} + 30 kg S ha^{-1}) and were replicated thrice. The Ethiopian mustard and chickpea were sown at 45 and 30 cm row spacing in sole cropping while in intercropping Ethiopian mustard sown at 150 cm and Chickpea sown at 30 cm row spacing as (1:4) ratio. Crops were grown as per recommended package of practices. Ethiopian mustard and chickpea was matured in second fortnight of April in both the year of experimentation. Fertilizers were drilled in bands 8–10 cm below the surface. Full dose of phosphorus and sulphur as per treatments recommendation applied through urea, DAP and single superphosphate, respectively just before sowing of crops.

Plant samples were collected from 0.5 m^2 land area at different stages of crop growth and oven dried at 65^o C until constant weight. Dry matter (DM) was determined based on the fresh weight of sample plants and the moisture content of the subsamples. The yield data were recorded from each plot area and converted into tonnes per hectare. The mustard equivalent yield (MEY) was computed as below:

$$\text{MEY} = \frac{\text{Grain yield of chickpea (t/ha)}}{\text{Market price of mustard (Rs/t)}} \times \text{Market price of chickpea (Rs/t)}$$

Statistical analysis of data was carried out using standard analysis of variance (Gomez and Gomez, 1984). The significance of the treatment effect was determined using the *f*-test. To determine the significance of the difference between the means of two treatments, least significance difference (L.S.D.) was computed at 5% probability level.

Results and Discussion

The growth parameters of Ethiopian mustard were significantly influenced due to cropping systems. The plant height, dry matter accumulation and leaf area index (Table 1) higher with sole cropping and it remained at par with intercropped Ethiopian mustard with chickpea. This might be due to presence of competition between main crop and the intercrop for growth resources such as nutrients, moisture and solar radiation because of exhaustive nature of mustard (Jana *et al.,* 1995; Singh and Rana, 2006). The favorable climate and weather conditions did not affected and remained favorable for growth and development during the experimentation. Moisture conservation practices brought a significant improvement in the growth components (Table 1) of Ethiopian mustard and chickpea. It may be due to the availability of soil moisture for longer period during crop growth, maintained plant water status, soil temperature and lowered mechanical soil resistance. This could be attributed to reduce evaporation loss from soil surface and transpiration loss of moisture from leaf surface due to formation of rigid layer on the surface of leaves, which extend the moisture availability (Kaushik and Lal, 1997). Adequate availability of water to plants resulted in cell turgidity and eventually higher meristematic activity, leading to more foliage development, greater photosynthetic rate and consequently better plant growth and development. It was attributed to the fascinating role of phosphorus and sulphur in a number of functions related to growth, development, partitioning and translocation as well as utilization of photosynthetic substrate. Ghosh *et al.* (2009) also corroborates the above findings.

Yield of mustard and chickpea

Seed and stalk yield (Table 2) of Ethiopian mustard in cropping systems was found non-significant from that of sole Ethiopian mustard. This is because of non-significant differences in plant height and yield attributes, however, the yield levels of more than the expected. Seed yield of Ethiopian mustard was found to increase significantly with increasing levels of fertility during both the years. The fertility levels produced more yield over control. Increased seed yield with increasing fertility levels may be attributed to balance crop growth, which helped plant in putting forth more branches, dry matter accumulation, leaf area index (LAI) and increased

number of yield attributes. The stalk yield of Ethiopian mustard was observed to decrease but difference was non-significant in Ethiopian mustard + chickpea (1:4) over sole Ethiopian mustard because of low plant stand per meter row length. The stalk yield of Ethiopian mustard increased under moisture conservation practices bur required portion of this dry matter could not be translated into economic yield. The yield level of mustard was increased with each increasing levels of fertility. It was attributed due to fascinating role of phosphorus and sulphur in a number of functions related to growth, development, photosynthesis, partitioning and utilization of substrate. The response of rapeseed–mustard to P and S is determined by moisture availability, soil P status and yield level. Phosphorus stimulates seed setting, hastens maturity and enhances oil content. Sulphur is involved in oil synthesis and in many physiological functions like amino acid synthesis in addition to productivity. Application of P and S is also important in increasing the efficacy of other nutrients. Such a response to increasing P and S levels might be ascribed to adequate supply of these nutrients that resulted in higher production of photosynthates and their translocation to sink (Piri and Sharma (2006).

The seed and stover yield of chickpea were significantly higher (Table 2) under sole planting of chickpea. It is because of lesser plant population and shading effect of Ethiopian mustard over chickpea. Moreover, the dry matter produced was not translated into economic yield under intercropping system. These results were in close conformity with the results of Kushwaha (1992). An increasing trend in seed and stover yield of chickpea under moisture conservation practices during both the years which is mainly attributed by proper growth and development of plants due to moisture availability for longer period. But the proportion of biomass was not properly translocated to the sink. Therefore, non-significantly values of harvest index were noted under moisture conservation practices. Tripathi *et al.* (2002) also reported similar results. Better growth and development of crop plants due to phosphorus and sulphur supply and uptake of more nutrients might have increased the supply of assimilates to seed, which ultimately gained more weight in terms of economic yield and biomass production. Increase in seed and straw yield was also reported by Ali *et al*. (2000) and Mansur *et al.* (2009).

Conclusion

The results of the present investigation suggest that intercropping system of mustard and chickpea provided higher growth, productivity and profitability under limited moisture condition. It may be concluded that adoption of Ethiopian mustard + chickpea intercropping system with moisture conservation practices (FYM@ 5t ha^{-1} + Organic mulch + Kaolin 6% spray) and recommended dose of fertilizer (60 kg P_2O_5 ha^{-1} + 30 kg S ha^{-1}) would be a better option to sustain the productivity and profitability, to increase the moisture-use efficiency and to maintain the soil fertility in limited moisture conditions.

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Table 1. Growth attributes of mustard and chickpea as influenced by cropping system, moisture conservation practice and fertility levels.

Treatments	Plant Height(cm)		Dry Matter Accumulation (g/m) (g/m^2)		LAI	
	E.Mustard	Chickpea	E.Mustard	Chickpea	E.Mustard	Chickpea
Cropping systems						
C_1	184.8	-	1283.2	-	5.2	-
C_2	-	59.5	-	191.1	-	3.6
C_3	178.0	60.2	1135.0	144.6	5.05	3.4
S.Em±	2.05	0.6	14.3	2.1	0.45	0.06
CD (P=0.05)	6.25	NS	47.85	6.5	NS	0.19
Moisture conservation practices						
M_0	177.5	57.8	1128.8	164.4	5	3.45
M_1	190.1	61.9	1289.3	172.3	5.25	3.65
S.Em±	2.05	0.6	14.3	2.1	0.45	0.06
CD (P=0.05)	6.2	2.05	47.8	6.5	0.14	0.19
Fertility levels						
F_0	172.7	55.6	1073.3	153.8	4.85	3.0
F_1	176.7	57.25	1138.9	160.4	5.05	3.3
F_2	182.0	60.05	1215.0	167.2	5.25	3.5
F_3	185.3	61.3	1267.4	173.4	5.05	3.7
F_4	190.2	64.65	1362.4	187.1	5.5	4.1
S.Em±	4.1	1.3	21.6	5.1	0.07	0.08
CD (P=0.05)	11.9	3.8	63.7	15.1	0.22	0.26

Table 2. Seed yield, stalk/Stover yield of mustard and chickpea as influenced by cropping system, moisture conservation practice and fertility levels

Treatments	Seed Yield (t/ha)		Stalk/stover Yield (t/ha)		MEY	LER
	E.Mustard	Chickpea	E.Mustard	Chickpea		
Cropping systems						
C_1	1.59	-	4.98	-	1.56	1.0
C_2	-	1.85	-	3.09	1.77	1.0
C_3	1.49	0.97	4.70	2.64	2.32	1.42
S.Em±	0.04	0.02	0.09	0.28	0.04	0.02
CD (P=0.05)	NS	0.06	NS	0.505	0.14	0.07
Moisture conservation practices						
M_0	1.46	1.36	4.49	2.775	1.83	1.14
M_1	1.63	1.45	5.19	2.96	1.95	1.15
S.Em±	0.04	0.02	0.09	0.28	0.03	0.02
CD (P=0.05)	0.14	0.06	0.33	0.505	0.11	NS
Fertility levels						
F_0	1.4	1.2	4.38	2.695	1.66	1.12
F_1	1.48	1.34	4.7	2.79	1.80	1.15
F_2	1.54	1.41	4.84	2.92	1.89	1.13
F_3	1.61	1.51	5.12	2.95	1.99	1.14
F_4	1.69	1.57	5.16	3	2.08	1.16
S.Em±	0.03	0.35	0.14	0.235	0.02	0.05
CD (P=0.05)	0.08	1.02	0.43	0.755	0.07	NS

Genetic variability in Indian mustard (*Brassica juncea* L. Czernj & Cosson) over six environments in alfisol of Jharkhand

Jay Lal Mahto* and Z. A. Haider

Department of Plant Breeding and Genetics, Birsa Agricultural University, Ranchi 834 006, Jharkhand, INDIA.
Corresponding author: jaylalmahto@ymail.com

Abstract

The analysis of variance revealed highly significant variation among the genotypes for all the traits studied in all six environments. Genotypic variance of environment six (E_6) showed the superiority for days to flowering, number of primary branches/plant, number of siliquae/plant, number of seeds/siliqua and seed yield/plant to other five environments. Phenotypic coefficient of variance of environment six (E_6) showed the superiority for number of secondary branches/plant, number of siliquae/plant and number of seeds/siliqua to other five environments. Genotypic coefficient of variance of environment four (E_4) showed the superiority for number of secondary branches/plant, plant height, harvest index and seed yield/plant to other five environments. Heritability (broad sense) in percent, genetic advance and genetic advance in percent of mean of environment four (E_4) showed the superiority for number of secondary branches/plant, plant height, number of siliquae/plant and harvest index to other five environments.

Key words: *Brassica juncea*, Genetic advance, GCV, heritability, mustard, PCV, Variability

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. Mustard (*Brassica juncea* L.) is important winter oilseed crop. Its yield and yield traits like other crops are more affected by environment. Very scanty study was done genetic variability over environments. In present study was undertaken to study the genetic variability over six different environments.

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). Estimation of variability was done as per standard method.

Results and Discussion

The analysis of variance revealed highly significant variation among the genotypes for all the traits studied in all six environments. These differences could be used in distinguishing genotypes on the basis of their morphology. Genotypic variance of environment six (E_6) showed the superiority for days to flowering, number of primary branches/plant, number of siliquae/plant, number of seeds/siliqua and seed yield/plant to other five environments. In same way genotypic variance of environment one (E_1) showed the superiority for days to maturity and 1000-seed weight to other five environments. Genotypic variance of environment four (E_4) showed the superiority for number of secondary branches/plant and harvest index to other five environments. In same way genotypic variance of environment five (E_5) showed the superiority for Plant height to other five environments. Phenotypic coefficient of variance of environment six (E_6) showed the superiority for number of secondary branches/plant, number of siliquae/plant and number of seeds/siliqua to other five environments. Environment one (E_1) showed phenotypic coefficient of variance superiority for days to flowering and number of primary branches/plant to other five environments. Phenotypic coefficient of variance of environment three (E_3) showed the superiority for Plant height and Days to maturity to other five environments. Environment four (E_4) showed phenotypic coefficient of variance superiority for days to flowering and number of primary branches/plant to other five environments. Genotypic coefficient of variance of environment four (E_4) showed the superiority for number of secondary branches/plant, plant height, harvest index and seed yield/plant to other five environments. Environment one (E_1) showed genotypic coefficient of variance superiority for days to maturity and 1000-seed weight to other five environments. Genotypic coefficient of variance of environment three (E_3) showed the superiority for number of primary branches/plant and number of siliquae/plant to other five environments. Heritability (broad sense) in percent of environment four (E_4) showed the superiority for number of secondary branches/plant, plant height, number of siliquae/plant, days to maturity, harvest index and 1000-seed weight to other five environments. Genetic advance of environment four (E_4) showed the superiority for number of secondary branches/plant, plant height, number of siliquae/plant and harvest index to other five environments. Genetic advance in percent of mean of environment four (E_4) showed the superiority for number of secondary branches/plant, plant height, number of siliquae/plant, harvest index and seed yield/plant to other five environments.

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Table 1. Variability studies of different environments

Parameters		1	2	3	4	5	6	7	8	9	10
***Genotypic* variance**	E_1	56.146	0.772	3.311	196.28	2030.816	4.385	59.484	0.004	0.368	7.235
	E_2	23.153	0.244	10.538	213.262	6587.693	1.231	14.709	0.003	0.199	6.570
	E_3	55.305	0.878	8.977	177.212	8183.809	4.546	34.678	0.003	0.190	3.715
	E_4	39.788	0.887	11.699	209.389	6726.226	4.746	32.639	0.006	0.261	5.715
	E_5	18.831	0.336	8.1755	217.604	5073.182	1.261	15.423	0.002	0.180	33.112
	E_6	97.549	0.977	9.661	189.765	12399.16	5.237	39.264	0.002	0.281	35.922
Phenotypic	E_1	112.069	3.089	20.158	357.496	10513.82	7.779	90.051	0.006	0.528	7.557

variance	E_2	65.443	1.479	30.802	457.003	13496.01	3.561	46.661	0.006	1.007	7.115
	E_3	138.637	0.708	23.786	561.431	12467.32	8.134	164.937	0.006	0.469	3.875
	E_4	76.288	2.078	16.373	393.735	7876.385	9.083	46.190	0.008	0.370	5.959
	E_5	58.150	2.391	50.676	444.365	14455.62	5.912	56.932	0.004	0.587	34.699
	E_6	141.819	4.867	165.271	603.748	55854.83	10.390	100.000	0.004	0.531	38.136
Error Variance	E_1	55.923	2.317	16.847	179.126	8483.004	2.394	40.567	0.002	0.160	0.322
	E_2	42.291	1.236	20.264	243.741	6908.317	2.330	31.952	0.003	0.908	0.645
	E_3	83.332	1.586	14.809	384.219	4283.509	3.588	130.259	0.003	0.279	0.160
	E_4	36.500	1.191	4.673	184.346	1150.159	4.337	13.551	0.002	0.109	0.244
	E_5	39.329	2.055	41.922	226.761	9382.441	4.651	41.509	0.002	0.407	1.087
	E_6	44.270	3.890	155.61	413.983	43455.71	5.153	60.736	0.002	0.250	3.814
Phenotypic Coefficient Of variance	E_1	18.820	45.98	78.98	16.290	74.905	27.187	9.092	45.19	24.86	82.05
	E_2	15.760	30.07	80.25	16.910	68.786	16.916	6.517	35.57	31.85	61.35
	E_3	17.730	34.24	93.39	20.870	97.290	27.576	10.762	41.43	22.84	69.780
	E_4	14.020	37.60	79.24	18.810	75.739	27.465	5.947	51.24	21.66	98.309
	E_5	14.430	34.96	148.310	16.130	61.437	20.579	7.255	30.81	24.84	92.53
	E_6	17.290	7.140	251.530	19.847	99.267	31.482	8.215	38.33	23.32	92.38
Genotypic Coefficient Of variance	E_1	13.320	22.98	32.01	11.780	32.922	20.412	7.390	36.90	20.75	80.29
	E_2	9.380	12.20	46.94	11.550	48.058	9.944	3.659	28.38	14.16	58.949
	E_3	11.200	25.480	57.38	11.730	78.824	20.615	4.935	27.933	14.535	68.325
	E_4	10.120	24.560	66.98	13.720	69.991	19.853	4.999	43.883	18.189	96.275
	E_5	8.210	13.100	61.64	11.290	36.396	9.504	3.776	20.172	13.753	91.071
	E_6	14.340	21.120	60.810	11.132	46.770	22.349	5.147	27.104	16.959	89.655
Heritability (Broad Sense) in Per cent	E_1	50.100	24.980	16.43	52.270	19.316	56.370	66.056	66.667	69.697	95.739
	E_2	35.380	16.460	34.21	46.670	48.812	34.56	31.523	63.636	19.762	92.34
	E_3	39.890	55.360	37.74	31.560	65.642	55.886	21.025	45.455	40.512	95.871
	E_4	52.150	42.670	71.460	53.180	85.397	52.249	70.663	73.333	70.501	95.905
	E_5	32.380	14.030	17.280	48.970	35.095	21.330	27.09	42.857	30.664	96.867
	E_6	68.780	20.070	5.850	31.459	22.199	50.397	39.264	50.000	52.875	94.19
Genetic Advance	E_1	10.930	0.900	1.52	20.870	40.799	3.239	12.913	0.106	1.043	5.422
	E_2	5.900	0.410	3.91	20.550	116.815	1.343	4.436	0.097	0.409	5.074
	E_3	9.680	1.440	3.79	15.410	150.986	3.283	5.562	0.069	0.572	3.888
	E_4	9.380	1.270	5.96	21.740	156.126	3.244	9.893	0.131	0.883	4.823
	E_5	5.090	0.450	2.53	21.265	86.922	1.068	4.211	0.052	0.484	11.755
	E_6	16.870	0.91	1.55	14.20	108.076	3.347	8.088	0.065	0.793	11.983
Genetic Advance In per cent Of mean	E_1	19.430	23.660	26.73	17.540	29.805	31.570	12.373	62.064	35.692	161.84
	E_2	11.490	10.20	56.56	16.260	69.167	12.043	4.232	46.628	12.965	116.69
	E_3	14.570	39.05	72.61	13.570	131.559	31.747	4.661	38.795	19.057	137.81
	E_4	15.060	33.05	116.64	20.610	133.238	29.561	8.657	77.413	31.462	194.22
	E_5	9.630	10.11	52.78	16.270	44.416	9.042	4.049	27.20	15.688	184.65
	E_6	24.500	19.49	30.290	12.756	108.076	32.684	6.644	39.48	25.40	179.25
Mean	E_1	56.244	3.829	5.684	118.944	136.889	10.259	104.37	0.171	2.923	3.350
	E_2	51.322	4.044	6.216	126.422	168.889	11.155	104.81	0.209	3.151	4.358
	E_3	66.411	3.678	5.222	113.522	114.767	10.342	119.33	0.179	2.999	2.821
	E_4	62.311	3.899	5.107	105.489	117.178	10.973	114.28	0.169	2.999	2.821
	E_5	52.833	4.422	4.800	130.668	195.700	11.815	104.00	0.192	3.085	6.36
	E_6	68.878	4.680	5.111	124.722	238.082	10.239	121.73	0.165	3.123	6.685
Standard Error of Mean ±	E_1	5.288	1.076	2.902	9.466	65.127	1.303	3.910	0.032	0.283	0.401
	E_2	4.598	0.788	3.183	11.039	58.772	1.079	3.997	0.039	0.636	0.522
	E_3	6.455	0.595	2.721	13.860	46.279	1.339	8.070	0.039	0.374	0.283
	E_4	4.272	0.772	1.529	9.601	23.981	1.473	2.603	0.032	0.233	0.349
	E_5	4.435	1.014	4.578	10.648	68.403	1.525	4.556	0.032	0.451	0.737
	E_6	4.705	1.395	8.821	224.84	147.404	1.605	5.511	0.032	0.354	1.052
CV in Per cent	E_1	13.300	39.830	72.210	11.255	67.283	17.958	5.297	26.092	13.685	16.939
	E_2	12.670	27.490	65.090	12.350	49.214	13.684	5.393	21.449	28.527	16.979
	E_3	13.746	22.880	73.690	17.270	57.027	18.316	9.564	30.599	17.613	14.179
	E_4	9.096	28.470	42.330	12.870	28.942	18.979	3.221	26.462	11.766	19.894
	E_5	11.870	32.420	134.890	11.520	49.496	18.253	6.195	23.292	20.681	16.378
	E_6	9.700	14.100	24.400	17.001	8.802	22.204	6.406	27.104	16.01	22.258
CD at 5 %	E_1	15.080	3.070	11.060	27.000	2372.258	3.224	9.677	0.078	0.700	0.993
	E_2	13.120	2.240	9.080	31.490	145.473	2.672	9.893	0.078	1.573	1.292
	E_3	18.410	1.700	7.760	39.530	114.550	3.315	19.976	0.096	0.925	0.700
	E_4	13.180	2.200	4.360	27.380	59.360	3.645	6.443	0.078	0.578	0.865
	E_5	12.650	2.890	13.060	30.370	195.760	3.775	11.276	0.078	1.117	1.825
	E_6	13.414	3.912	25.221	42.822	42.122	4.623	15.739	0.090	1.011	3.007

1. Days to flowering, 2. Number of primary branches/plant, 3. Number of secondary branches/plant, 4. Plant height, 5. Number of siliquae/plant, 6. Number of seeds/siliqua, 7. Days to maturity, 8. Harvest index, 9. 1000-seed weight and 10. Seed yield/plant.

Exhibition of hormesis during allelopathic investigations in turnip (*Brassica rapa* L.)

Chandreshwar Prasad

Department of Botany, Vinoba Bhave University, Hazaribag – 825 301, India
Corresponding author: c.prasad@yahoo.com

Abstract

Aqueous leaf extracts of some medicinal plants viz. neem (*Azadirachta indica* A. Juss.), periwinkle (*Catharanthus roseus* Don.), holy basil (*Ocimum sanctum* L.) and Malabar nut (*Adhatoda vasica* Nees.) had stimulating effects on various yield components of turnip (*Brassica rapa* L.) at the lower or moderately higher doses, but extremely higher doses of the same extract were found deleterious, indicating hormesis.

Key words: hormesis, allelopathy, medicinal plants, extract, dose, turnip.

Introduction

Allelopathy is a kind of plant – plant interaction mediated through the release of chemical substances by the plant which is detrimental to the other growing in vicinity (2, 10, 12, 13, 14, 17). Biochemical interactions occur when the allelochemicals (secondary plant metabolites) produced by one plant escape into environment and influence the survival, growth, development and reproduction of another plant (s) growing nearby. Extensive researches have been done on the agricultural crops for getting superior varieties, for obtaining more yield, disease resistance and quality improvement, but very little work has been done to know the allelopathic impact of the medicinal plants on the survival, growth, development and reproduction of valuable crops cultivated in close association with them. Keeping this is view, present investigation was carried out to know the allelopathic influence of four medicinal plants viz. neem (*Azadirachta indica* A. Juss.), periwinkle (*Catharanthus roseus* Don.), holy basil (*Ocimum sanctum* L.) and malabarnut (*Adhatoda vasica* Nees.) on the yield components of a root crop plant, turnip (*Brassica rapa* L.).

Materials and Methods

'Rose Red' cultivar of turnip constituted the material for present investigation. To make aqueous leaf extract, 250g mature photosynthetically active leaves were detached from the plant body of neem, periwinkle, holy basil and Malabar nut and kept separately. They were dried at 60^0C, grinned to pass through 1 mm screen and stored at room temperature. Sterilized distilled water was used to make the leaf extract separately in 50 : 1 (V/W) Water : Sample ratio. After this, it was kept in refrigerator for 18 hours. The suspension was centrifuged at 1000g for 15 minutes, 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. Seed treatment was given for 24 hours. For Control, they were soaked in distilled water only. The treated seeds were thoroughly washed in double distilled water and sown immediately in different pots of equal size having homogenous soil, along with the control to raise M1 plants. The M2 plants were grown from the seeds obtained from M1 through selfing. 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.

Results and Discussion

The leaf extract of periwinkle (Table 1) and malabar nut (Table 2) had deleterious effect on the seed and seedling traits like seed germination, seedling survival, hypocotyl length and cotyledon area of turnip. There was gradual decrease in the above traits from lower to higher used concentrations treatment in M1 generation. Some recovery took place in M2 generation at all the used doses, but not up to the extent of control. So far as the effect of aqueous leaf extract of neem was concerned, there was progressive increase from 20% to 40% concentrations treatment, followed by a gradual decrease from 60% to 100% in M1 generation with regard to per cent seed germination, seedling survival, hypoctyl length, cotyledon area, number of leaves/plant, root weight, plant height, branches/plant, silique/plant and 100-seed weight of turnip (Table1). However, situation was different in case of holy basil treatment where a progressive increase in the above traits was noted from 20% to 80% concentrations, followed by a drastic decline at 100% in M1 generation (Table 2). Further improvement in all of the above traits took place in M2 generation at all the doses in case of neem (Table 1) and holy basil treatments (Table 2). The leaf extract treatment of malabar nut demonstrated stimulatory effect on the number of leaves/plant, plant height, branches/plant, silique/plant and 100 – seed weight of turnip (Table2). There was a gradual increase in these traits from 20% to 60% concentrations treatment, followed by a stepwise decrease from 80% to 100% in M1 generation. In case of periwinkle treatment, a gradual increase in the above traits was noted from 20% to 80% concentrations treatment, followed by a sharp decline at 100% in M1 generation (Table 1). On the whole, maximum stimulatory effect in case of neem extract treatment on the yield components of turnip was noted at 40% concentration treatment (Table1); and in case of holy basil it was observed at 80% concentration (Table 2). With regard to malabar nut treatment, it was demonstrated at 60% concentration (Table 2); and in periwinkle it was detected at 80% concentration treatment (Table1). In all the cases, 100% concentration treatment was found deleterious.

Theophrastus (1493-1541), regarded by many as the father of toxicology, said “All things are poison and nothing is without poison; only the dose makes a thing poison.” With this statement, he considered apparent safety of the toxicants at low doses. It is generally seen that the phytotoxins (allelochemicals) that inhibit the growth of certain plant species at higher concentrations can stimulate the growth of the same or different species at the lower concentrations (14). In was suggested that the biologically active substances act on the hormonal process which regulate plant growth and that plant response is dependent on the concentration of these compounds. Allelopathic effects may be species specific and even cultivar specific (9). This is also the case with compounds like pesticides which are generally used as toxicants (15). The stimulatory effect of a low dose of a toxicant is called hormesis. The term was first used by Southam and Erlich (16) to describe the effect of an Oak bark compound that promoted fungal growth at low doses, but strongly inhibited it at higher doses. Under the present investigation the lower or moderately higher concentrations of the aqueous leaf extracts of medicinal plants exhibited stimulatory effect on a number of yield components of turnip, but their higher concentrations were inhibitory, indicating hormesis. It appears that several secondary metabolites, once released from the plant material, act jointly and thus hormesis is pronounced with the mixture of allelochemicals (6, 12, 13). The developmental stages of allelopathic plant also play important role in eliciting a hormetic response (3). Hormesis has been found within all groups of organisms, from bacteria and fungi to

higher plants and animals (1). Unfortunately less documentations on hormesis exists in plants. Plants could escape unfavorable growth conditions by producing more seeds which gives next favorable conditions (4). The induction of defense mechanisms induced by free radicals of oxygen can lead to increased growth in presence of low doses of phytotoxic chemicals (7). The stimulatory responses observed at low levels of chemical stress usually lead to an over-all improvement in the fitness of an organism (5, 11). Turnip bears small-sized seeds, and it has been found that the species having small seeds are more adversely affected at the higher concentrations of an aqueous plant extract (8).

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Exhibition of hormesis during allelopathic investigations in turnip (*Brassica rapa* L.)

Chandreshwar Prasad

Table 1. Effect of the leaf extracts of medicinal plants on yield components of turnip.

Plant Species	Dose (%)	Generation	Seed germination (%) (Mean)	Seedling survival (%) (Mean)	Hypocotyl Length (mm) (Mean)	Cotyledon area (mm^2) (Mean)	Plant height (cm) (Mean)	Leaves/ plant (Mean)	Branches/ plant (Mean)	Root weight (g) (Mean)	Silique/ plant (Mean)	100 – seed weight (mg) (Mean)
Neem	Control	M_1	63.5	66.7	11.4	15.7	71.6	5.4	9.6	168.3	68.0	156.4
		M_2	62.5	63.3	11.2	10.2	71.5	5.2	9.0	172.0	68.7	159.5
	20	M_1	80.0**	67.3**	20.0**	18.9	78.4**	6.9**	11.2**	185.7**	72.8**	168.1**
		M_2	82.5**	74.7**	22.7**	21.7	79.2**	7.0**	12.3**	187.3**	77.4**	170.3**
	40	M_1	88.0**	68.0**	31.3**	34.8	92.2**	9.6**	14.9**	438.7**	84.8**	178.5**
		M_2	90.0**	83.3**	31.0**	43.7	94.6**	9.8**	15.3**	445.4**	90.6**	181.9**
	60	M_1	83.0**	56.7**	25.0**	26.8	88.9**	8.4**	12.4**	281.2**	82.7**	174.9**
		M_2	85.0**	76.7**	27.0**	33.8	90.8**	8.7**	13.0**	279.2**	89.3**	175.5**
	80	M_1	70.0*	40.0**	19.3**	19.2	74.6**	5.5**	10.9**	261.8**	79.8**	166.4**
		M_2	75.0*	60.0**	21.3**	22.4	83.1**	7.0**	12.5**	262.6**	82.0**	166.0**
	100	M_1	62.0	33.3**	12.4**	15.4	66.5**	4.3**	8.6**	160.8**	65.5**	155.9
		M_2	75.0*	37.7**	14.5**	15.1	75.2**	5.0**	9.8*	162.8**	66.9**	154.4
Periwinkle	Control	M_1	71.0	65.8	18.5	31.7	89.2	26.2	16.7	170.4	78.2	158.0
		M_2	72.3	65.7	18.1	33.8	89.8	26.2	16.4	175.4	80.0	159.0
	20	M_1	67.0	62.0	18.1	32.1	85.4*	24.8**	15.5**	164.6	78.0	155.0
		M_2	69.0	63.0	18.1	34.0	91.2	25.8	16.5	168.8	77.8	166.0
	40	M_1	60.0*	56.4**	17.2**	30.1	60.8**	21.2**	14.2**	172.0	77.6	153.0
		M_2	65.0*	60.0*	17.5**	32.9	80.2**	22.6**	16.4	173.6	77.8	170.0*
	60	M_1	50.6**	54.9**	16.7**	30.5	54.8**	16.5**	14.8**	180.0**	77.6	150.0
		M_2	52.0**	56.4**	16.4**	32.6	67.6**	22.5**	17.3	184.2**	77.2	172.0*
	80	M_1	30.2**	20.0**	15.9**	25.0	74.6	29.2**	27.7	220.0**	100.4**	166.0
		M_2	38.6**	35.0**	18.1	33.3	81.2**	34.8**	28.0**	242.0**	103.0**	178.0**
	100	M_1	5.2**	9.0**	9.5**	15.5	72.0	24.9**	17.5	112.8**	72.2**	122.0**
		M_2	9.6**	12.0**	10.7**	21.1	74.2**	27.2**	20.1**	130.4**	75.2**	141.0**

** Significent from the respective Control at 1% level. * Significent from the respective Control at 5% level

Table 2. Effect of the leaf extracts of medicinal plants on yield components of turnip

Plant Species	Dose (%)	Generation	Seed germination (%) (Mean)	Seedling survival (%) (Mean)	Hypocotyl length (mm) (Mean)	Cotyledon area (mm^2) (Mean)	Leaves/plant (Mean)	Plant height (cm) (Mean)	Branches/ plant (Mean)	Root weight (g) (Mean)	Silique/ plant (Mean)	100 – seed weight (mg) (Mean)
Holy basil	Control	M_1	60.7	54.4	10.9	72.9	6.6	71.1	8.2	162.0	66.4	157.6
		M_2	62.2	56.2	11.1	73.7	6.9	72.1	8.1	163.8	66.1	160.3
	20	M_1	62.6	57.2	12.3	75.9	8.3	73.7	9.5	169.1	68.0	161.2
		M_2	62.9	59.8	14.4	76.4	9.1	80.3	10.1	173.9	69.8	164.0
	40	M_1	65.6	61.9	17.5	77.9	9.4	80.9	10.9	263.1	72.7	165.8
		M_2	65.6	62.9	21.3	79.1	10.1	82.6	12.4	266.2	76.7	166.5
	60	M_1	67.2	65.6	24.9	78.9	10.4	87.4	11.7	283.9	82.7	167.8
		M_2	69.1	68.3	27.3	82.2	11.8	88.9	13.0	299.7	86.0	172.1
	80	M_1	70.7	70.9	30.9	84.3	10.6	92.8	14.3	294.0	91.7	170.2
		M_2	71.9	71.9	30.9	84.9	12.9	94.5	15.5	304.1	92.1	174.9
	100	M_1	58.7	66.9	16.9	81.8	8.4	74.3	12.1	189.2	72.8	152.0
		M_2	62.0	68.9	17.3	82.6	8.6	82.4	13.3	187.2	74.3	156.5
	CD at 5% level	M_1	0.75	0.56	0.58	0.13	0.44	3.10	0.54	4.96	2.53	1.56
		M_2	0.46	1.15	0.49	0.73	0.74	2.70	0.54	10.22	3.07	0.99
Malabar nut	Control	M_1	88.4	85.4	35.0	48.3	12.1	95.6	11.9	204.8	195.1	156.4
		M_2	88.8	86.7	35.1	47.9	11.9	96.9	12.5	206.8	192.3	158.1
	20	M_1	82.7	80.5	29.7	43.3	14.0	102.0	12.1	216.1	239.9	162.7
		M_2	83.7	81.7	32.3	44.0	15.9	105.5	13.9	220.2	243.6	163.5
	40	M_1	66.5	70.7	25.0	40.2	15.9	108.0	13.1	228.6	542.4	165.0
		M_2	67.9	72.3	27.8	41.7	18.0	110.3	15.5	230.3	549.8	165.9
	60	M_1	57.9	60.9	20.2	35.6	18.1	111.1	14.9	245.4	606.6	171.4
		M_2	58.1	62.9	23.0	37.1	19.7	113.9	17.0	249.0	609.1	174.6
	80	M_1	33.3	41.1	15.9	30.4	11.6	94.4	10.2	107.4	276.7	166.9
		M_2	34.3	43.6	18.9	32.5	12.5	97.4	13.0	107.3	285.4	166.7
	100	M_1	23.1	31.1	9.9	26.2	9.7	76.6	8.2	73.9	151.1	151.7
		M_2	24.4	33.7	13.0	27.1	11.0	78.5	10.9	76.1	153.7	153.2
	CD at 5% level	M_1	1.83	2.00	0.67	0.92	0.99	6.03	1.07	5.74	10.95	2.86
		M_2	1.48	1.56	0.62	0.75	0.97	2.69	1.05	7.01	6.57	2.12

CRUCIFERAE NEWSLETTER Nr. 33

Instructions to the authors – 2013

Deadline for contribution submission: December 1st 2013

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.

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