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Research Article

Identification and Release of High Yielding and High Oil Containing Rapeseed for Terai, Inner Terai and Mid Hill of Nepal

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Abstract

Rapeseed (Brassica spp) is third most important edible oilseeds of the world after soybean and palm oil. In case of Nepal, Rapeseed are the 1st crop for the production of oil seed. However, there was a lack of elite high yielding variety of rapeseed having wide range of adaptability and stability. With the objective of identifying of high yielding variety, Oilseed Research Program, Narc, Nepal was continuously doing series of research like Observation trial, Initial evaluation trial, Coordinated varietal trial and Coordinated farmer trial with the local and exotic genotype of rapeseed for consecutive 7 years. As a result, elite genotype " ICT 2001-35" was identified as high yielding with the yield of 1201 kg/ha, protein with 23.22 % , fat with 46.48% (dry basis) and with wider adaptability and stability. Hope this variety will be mainstream in the production of rapeseed and contribute for the oil production in Nepal.

Keywords: oilseed, high yielding varieties, oil content, adaptability and stability.

Introduction

Rapeseed and mustard are third most important edible oilseeds of the world after soybean and palm oil. While seeing the history of Rapeseed, it was a result of spontaneous hybridization between turnip rape (*B. rapa*) and cabbage (*B. oleraceae*) about 7500 years ago (Chalhoub *et al*., 2014). Regarding the cultivation, since 4000 BC, India was supposed to cultivate the rapeseed from where it was extended to the rest of the Asian countries.

There are multiple use of the Rapeseed ranging from the edible oil to the honey production. Brassicaceae are grown mainly grown for the source of edible oil, however it is also grown for honey production with the help of honey bee and even for the ornamental Plants (Al-Shehbaz *et al*., 2006) and (Meyer *et al*., 2013). Biodiesel Rapeseed oil was reported to have a low cold point (0^{oC}) and pour point ($-15^{o}C$), which was much lower than that of other feedstock (Peterson *et al*., 1997), Due to the low cold point ($0^{o}C$) and

pour point (-15ºC), rapeseed oil are considered as good biodiesel by which and which rapeseed is the favorite oil crop for biodiesel production in Europe (Peterson ,1997), which accounted for 50 to 70% of European biodiesel production (Zentková *et al*., 2013).

Rapeseed meals can be used to feed ruminants, poultry, fish, and crustaceans. Incorporation of rapeseed meals in animal diets implies a balance in protein ratio, which consequently has an impact on palatability and feed intake, body performance, and the production of milk, meat, or eggs. The flowers of the rapeseed make the environment beautiful with the diverse color and attack many pollinators and honey bees with other beneficial insects. In addition to this, rapeseed also helps to boost up the growth of other crops and also helps in healing the effect of heavy metals and helps in boosting the health of soil as well.

The rapeseed and mustard seed contain 40-45% oil, 24% protein. Rapeseed and mustard oil are nutritionally far superior to any other vegetable oils, because of sufficiently low level of saturated fatty acids (7%), moderate level of poly unsaturated fatty acids linoleic (omega-6) and linolenic (omega-3) which is highly balanced (12:10) and higher amount of monounsaturated fatty acids like oleic and erucic acid (70%). Rapeseed and mustard oil are safe for healthy people as well as for people with weak heart and those suffering from other chronic diseases. About 70 million tons (MT, yield) of rapeseed are produced per year around the world, involving 66 countries: 34 countries in Europe, 15 countries in Asia, 9 countries in America, 6 countries in Africa, and 2 countries in Oceania (Daun *et al*., 2015). In a recent study that compared yield, oil, and protein from different cultivars sown at different periods of the year, it was revealed that the cultivar sown in mid- atum displayed the best performance in grain yield, oil productivity and oleic acid content (Confortin *et al*., 2019).

In context to Nepal, Rape seed is gaining popularity day by day and as compared to previous year, its area and production is in increasing trend. The area under Rapeseed cultivation in Nepal was 196121 ha, production 214, 055 mt and productivity 1.09 mt /ha (Moald, 2021) but substantial amount of acreage has been found under mixed cropping with wheat, lentil, chickpea and linseed (Ghimire *et al*., 2001). Regarding the research and Development of the agriculture in Nepal, Nepal Agricultural Research Council (NARC) is the main functional governmental body. Nepal Agricultural Research Council (NARC) was established in 1991 as an autonomous organization under "Nepal Agricultural Research Council Act - 1991" to conduct agricultural research in the country to uplift the economic level of the people. It has objective of conducting qualitative studies and researches on different aspects of agriculture, identifying the existing problems in agriculture and find out the solution and to assist government in formulation of agricultural policies and strategies. Under different commodity program, Oilseed Research Program is also one of the commodities programs looking after the research and development of the oilseed crops likes groundnut, Rapeseed, Mustard, Linseed, Sunflower etc. Up to the date, 8 varieties (T-9, Bikash, Pragati, Lumle tori-1, Unnati, Preeti, Morang tori 2, Surkhet local etc) has been release for the cultivation in Nepal among which Unnati, Preeti and Morang tori 2 are popular having an average yield potential of 1.5. The limited numbers of varieties and increasing cultivated are of Rapeseed year by year shows that there is indispensable need of better breeding technique and better screening techniques to increase the yield potential of this crop. The unavailability of high yielding varieties may be one of the causes of low yield. On the other hand, very limited genetic stock with narrow genetic base is available at our condition. Considering these points in view, to select and release high yielding lines of mustard, series of trials like Coordinated varietal trials (CVT) and Coordinated Farmers Field Trial (CFFT) were conducted at Oilseed Research Program, Nawalpur, Parwanipur and Surkhet.

Methodology

14 Local and Exotic germplasm selected from Observation nursery and Initial Yield trails were evaluated in Coordinated varietal trial under different environment condition of Nepal (Oil Seed Research Program, Sarlahi, Agricultural Research Directorate Mithila Province, Parwanipur, Agricultural Research Directorate Karnali Province for 2 different on succeeding year, 2013 and 2014. Coordinated Varietal Trial was conducted in Random Complete Block Design (RCBD) with 14 Genotypes including local genotypes in 3 replications with the plot size of 5 x 2.1 m^2. Yield and yield attributing trait like Silique per plant, seed per silique and thousand grain weight was observed. Among the 14 genotypes, 5 genotypes were selected for Coordinated Farmer field Trials in the same location in 2013, 2014 (ORP-Annual Report 2014/15, 2015/16) with plot size of 50 m^2 where each farmer was considered as Replication. Chemical fertilizers were applied @ 60:40:20 kg/ha. Similarly, nutrient analysis (moisture, fat and protein content) was done in National Food Technology Research Centre, Narc. Computer based Statistical software like Crop stat and ADEL-R was used to analyze the data.

Result

Coordinated Varietal Trial (2013)

Coordinated Varietal Trial (CVT) is a trial which is conducted between the coordination of the research station in different ecological location. This type of trial helps to find out the performance of the genotypes in the different ecological condition. In this research, CVT was conducted in Nawalpur at Oil seed Research program, in Parwanipur at Regional Agriculture Research Station and in Surkhet at

Agriculture Research Station for two years in 2013 and 2014 A.D. different parameters were observed and result are shown in the Table 1-9.

Days to Maturity:

In 2013, In case of Days to maturity, genotypes were found to be significantly different in parwanipur and Surkhet whereas non-significant in Nawalpur. In an average of three location, highest days of maturity was observed in Uttara (91 DAS) and lowest days of maturity was observed in local Check (79 DAS). In 2014, Genotypes were found to be significantly different to each other in all three locations in context to Days to maturity. In an average of three location, highest days of maturity was observed in Uttara (88 DAS) and lowest days of maturity was observed in local Check (78 DAS) (Table 1).

Silique Per Plant:

In 2013, genotypes were found to be non-significant in all the trial area for the Silique per plant. However, in an average, highest number of Silique per plant was observed in ICT 21003-35 with a value of 66 number of silique per plant and lowest was 54 which was observed in ICT 2002-11. In case of 2014, genotypes were found to be non-significant as well in all the trial area for the Silique per plant. However, in an average, highest number of Silique per plant was 90 which was observed in ICT 2001-34 and Preeti whereas lowest number of Silique was 64 which was observed in ICT 2001-2 (Table 2).

Table 1: Days to Maturity.

EN	Genotypes	Days to maturity (2013)				Days to maturity (Gram) (2014)			
		Nawalpur	Parwanipur	Surkhet	Mean	Nawalpur	Parwanipur	Surkhet	Mean
1	ICT 2001-2	84	94	80	86.00	80	90	81	83.67
2	ICT 2001-13	86	95	83	88.00	78	90	83	83.67
3	ICT 2002-9	82	94	82	86.00	77	91	82	83.33
4	ICT 2002-11	83	95	80	86.00	81	91	80	84.00
5	ICT 2002-16	84	93	79	85.33	79	92	80	83.67
6	Uttara	89	98	85	90.67	87	93	85	88.33
7	ICT 2002-24	86	97	79	87.33	78	89	80	82.33
8	ACC# 5738	79	94	79	84.00	81	90	80	83.67
9	ICT 2001-35	82	93	81	85.33	80	90	81	83.67
10	ICT 2001-34	79	94	79	84.00	77	89	80	82.00
11	ICT 2001-41	86	94	79	86.33	79	91	79	83.00
12	Preeti	84	93	80	85.67	76	88	81	81.67
13	Morang 2	80	93	83	85.33	78	90	84	84.00
14	Local ch	79	78	80	79.00	77	78	80	78.33
	F test	Ns	*	*		**	*	**	
	CV %	4.7	1.59	2.1		2.8	1.9	1.8	
	GM	83	94.4	80.6		78.9	90	81	
	Lsd 0.05	--	1.2	1.3		1.7	1	1.2	

Table 2: Silique Per Plant

EN	Genotypes	Silique per plant (2013)				Silique per plant (2014)			
		Nawalpur	Parwanipur	Surkhet	Mean	Nawalpur	Parwanipur	Surkhet	Mean
1	ICT 2001-2	59	52	85	65	64	52	77	64
2	ICT 2001-13	59	56	74	63	73	47	77	66
3	ICT 2002-9	76	42	71	63	62	51	113	75
4	ICT 2002-11	67.5	38	56	54	65	61	96	74
5	ICT 2002-16	55	45	70	57	67	55	92	71
6	Uttara	55.5	65	67	63	63	38	111	71
7	ICT 2002-24	52	52	84	63	64	58	115	79
8	ACC# 5738	68	55	79	67	77	55	124	85
9	ICT 2001-35	76	49	73	66	73	61	124	86
10	ICT 2001-34	62	43	73	59	66	56	147	90
11	ICT 2001-41	53	40	71	55	59	44	130	78
12	Preeti	52	56	87	65	90	55	125	90
13	Morang 2	68	44	77	63	72	50	97	73
14	Local ch	54.5	55	84	65	65	67	86	73
	F test	Ns	Ns	Ns		Ns	Ns	Ns	
	CV %	27	30	23		10.8	28	31.9	
	GM	122	49	75.6		68	52		
	Lsd 0.05	-	-			-	--		

Seed Per Silique:

In 2013, genotypes were found to be non-significant in all the trial area for the Seed per Silique. In an average of three location, highest number of seed per Silique was observed in ICT 2001-13 (15). In 2014, genotypes were found to be non-significant in Nawalpur and Parwanipur whereas found to be significant in Surkhet. In an average, high number of seed per silique was observed in 7 different genotypes with the value of 14 number of seed per silique whereas lowest was observed in local check with a value of 12 number of seed per silique (Table 3).

Thousand Grain Weight:

In 2013, The Analysis of Variance (ANOVA) of Thousand grain weight (TGW) reveled that there is non-significant difference among the genotypes in all three area (Nawalpur, Surkhet and Parwanipur). However, in an average, highest number of TGW was observed in Uttara (3.10 gm) followed by ICT 2001-35 (3.07 gm). In 2014, genotypes was found to be significant in Surkhet whereas was found to be nonsignificant in Nawalpur and Parwanipur. In an average, highest TGW was observed in ACC# 5738 with weight of 3.63 and lowest was observed in ICT 2001-2 with a weight of 3.47 gm (Table 4).

Table 3: Seed Per Silique

EN	Genotypes	Seed per Silique (2013)				Seed per Silique (2014)			
		Nawalpur	Parwanipur	Surkhet	Mean	Nawalpur	Parwanipur	Surkhet	Mean
1	ICT 2001-2	15	12	12	13	16	13	10	13
2	ICT 2001-13	17	14	13	15	16	15	10	14
3	ICT 2002-9	16	14	12	14	18	14	9	14
4	ICT 2002-11	17	11	12	13	18	14	10	14
5	ICT 2002-16	17	13	11	14	18	12	9	13
6	Uttara	16	13	11	13	14	15	10	13
7	ICT 2002-24	13	14	11	13	16	14	9	13
8	ACC# 5738	14	12	12	13	16	15	10	14
9	ICT 2001-35	14	13	12	13	16	15	10	14
10	ICT 2001-34	17	13	11	14	16	14	8	13
11	ICT 2001-41	18	13	12	14	16	14	11	14
12	Preeti	16	15	11	14	16	14	9	13
13	Morang 2	15	13	12	13	18	14	9	14
14	Local ch	15	14	11	13	16	13	8	12
	F test	Ns	Ns	Ns		Ns	Ns	*	
	CV %	17.5	12.5	15.7		18.9	10.4	10.4	
	GM	15.7	13	11.7		16	14	9.4	
	Lsd 0.05			-		-	-	0.7	

Table 4: Thousand Grain Weight

EN	Genotypes	TSW (Gram) (2013)				TSW (Gram) (2014)			
		Nawalpur	Parwanipur	Surkhet	Mean	Nawalpur	Parwanipur	Surkhet	Mean
1	ICT 2001-2	3	2.7	2.8	2.83	5.1	3.3	2	3.47
2	ICT 2001-13	2.8	2.6	2.8	2.73	5.3	3.2	2.1	3.53
3	ICT 2002-9	2.8	2.7	2.6	2.70	5	3.3	2.2	3.50
4	ICT 2002-11	2.9	3.1	3	3.00	5	3.4	2.3	3.57
5	ICT 2002-16	2.9	2.9	3.1	2.97	4.8	3.3	2	3.37
6	Uttara	2.9	3.6	2.8	3.10	5	3.3	2.1	3.47
7	ICT 2002-24	2.8	3	2.6	2.80	5	3.3	2.2	3.50
8	ACC# 5738	2.6	3	3	2.87	5.3	3.3	2.3	3.63
9	ICT 2001-35	3	3.3	2.9	3.07	5	3.3	2.2	3.50
10	ICT 2001-34	2.6	3.1	2.9	2.87	5.2	3.2	2.3	3.57
11	ICT 2001-41	2.9	2.3	2.9	2.70	4.9	3.2	2.3	3.47
12	Preeti	2.7	3	3	2.90	5	3.3	2.4	3.57
13	Morang 2	3	2.8	3.1	2.97	4.9	3.6	2.4	3.63
14	Local ch	2.9	3.3	2.7	2.97	3	2.5	2.1	2.53
	F test	Ns	Ns	Ns		Ns	Ns	*	
	CV %	7.7	19.1	7		7.7	5.2	6.6	
	GM	2.8	2.9	2.8		5	3.3	2.2	
	Lsd 0.05	-	-	-		-	-	0.1	

Yield Per Hectare:

In 2013, the analysis of variance (ANOVA) of Yield hectare was found to be non-significant in Nawalpur and Surkhet whereas was significant in Parwanipur. In an average highest yield was 1283 kg/ha which was observed in ICT 2001-35 and lowest was 1038 kg/ha observe in ICT 2002-24. In year 2014, genotype was found to be significant for the yield per hectare in Surkhet whereas was nonsignificant in Parwanipur and Nawalpur. The highest yield per hectares in an average was 929 kg/ha which was observed in ICT 2001-35 and lowest was observed in Local check with an yield of 582 kg/ha (Table 5).

Coordination Farmer Field Varietal Trial

It is also a type of experimental trial conducted in farmers field by the farmer in close coordination with the researcher. The main objective of this trial was to observed the performance of the crop in the farmers filed. In this trial, out of 14 genotypes tested in Coordinated varietal trial, 4 promising genotypes (Acc# 9118, ACC# 9109, ICT 2001-35 and Morang 2) were selected and trial was conducted in different farmers filed in different year, viz. 2013 A.D., 2014 A.D. and 2016 A.D. In all the year, highest yield was observed in ICT 2001-35 with an average yield of 1288 kg/ha in 2013 A.D. and 1017 kg/ha in 2014 A.D. and 1090 kg/ha in 2016 A.D (Table 6-8).

Table 5: Yield per hectare

EN	Genotypes	Yield (kg/ha) (2013)				Yield (kg/ha) (2014)			
		Nawalpur	Parwanipur	Surkhet	Mean	Nawalpur	Parwanipur	Surkhet	Mean
1	ICT 2001-2	1260	1058	1345	1221	940	778	994	904
2	ICT 2001-13	1372	996	1400	1256	964	804	819	862
3	ICT 2002-9	1378	1003	1450	1277	1018	846	774	879
4	ICT 2002-11	1337	959	1586	1294	890	887	912	896
5	ICT 2002-16	1095	892	1234	1074	836	802	680	773
6	Uttara	1063	1078	1224	1122	720	723	829	757
7	ICT 2002-24	1224	843	1046	1038	848	844	717	803
8	ACC# 5738	1171	875	1323	1123	952	818	874	881
9	ICT 2001-35	1215	1230	1405	1283	888	965	935	929
10	ICT 2001-34	1246	932	1199	1126	1096	925	629	883
11	ICT 2001-41	1198	1128	1409	1245	872	831	1019	907
12	Preeti	1197	1064	1358	1206	990	787	873	883
13	Morang 2	1137	861	1554	1184	968	798	814	860
14	Local ch	1091	1121	1253	1155	636	564	545	582
	F test	NS	*	Ns		Ns	Ns	*	
	CV %	10.3	11.3	13.8		17.2	13.7	19	
	GM	1213	978	1342		904	831	815	
	Lsd 0.05	-	90			-	-	120	

Table 6 : Mean Yield (kg/ha) of CFFT rapeseed at different locations, 2013.

Genotypes	Karaiya, Chitwan	Nijgadh, Bara	Santpur, Rautahat	Haripur, Sarlahi	Parwanipur, Bara	Kavre, Kavreplanchok	Mean
ACC#9118	1350	1080	1406	1000	843	820	1083
ACC#9109	1350	1160	1466	1333	797	1000	1184
ICT 2001-35	1425	1480	1508	1600	763	953	1288
Morang-2	1635	1360	1153	1333	663	640	1130

Table 7 : Mean Yield (kg/ha) of CFFT rapeseed at different locations, 2014.

EN	Varieties	Chitwan	Sarlahi	Bara	Rauthat	Nijgadh	Mean
1	ACC#9118	825	900	1100	1090	983	980
2	ACC# 9109	923	1000	1000	1030	944	979
3	ICT 2001-35	1129	900	950	1160	950	1017
4	Unnati	1141	850	800	990	850	926
5	Loc check	821	700	700	730	700	730

Table 8 : Mean Yield (kg/ha) of CFFT rapeseed at different locations, 2016.

EN	Varieties	Haripr	Belach.	Chitwan	Surkhet	ABD	Salyan	Bara	Mean
1	ACC#9118	763	820	500	1875	782	1400	1150	1041
2	ACC#9109	875	654	652	1915	708	1200	1050	1007
3	ICT2001-35	975	838	703	2085	723	1250	1062	1090
4	Morang 2	812	968	693	2305	696	450	975	986

Table 9. Nutrient Analysis of ICT 2001-35

S.N.	Variety	Year	Moisture (%)	Ash (dry basis) (%)	Fat (%) (Dry basis)	Protein (%) (dry basis)
1	ICT 2001-35	2016	4.65	4.62	46.48	23.22

Nutrient Analysis

After ICT 2001-35 was found to be high yielding in all the farmer filed, it was sent for the nutrient analysis. In the analysis, this rapeseed was found to have 23.22 % protein in dry base, 46.48 % fat and 4.65% moisture (Table 9)

Release of Variety

After the analysis of all the trail (CVT, CFFT and nutrient Analysis) ICT 2001-35 was found to be promising genotype with high yield and high oil recovery rate with wider adaptability and stability, it was release as Nawalpur tori-4 in 2019 A.D. It consists of following characteristics.

Varietal Characteristics

a. Agronomic

i. Plant height (cm): 70-105 (Average 87)

ii. Days to flowering from seeding:28-38 days (Average 32 days)

iii. Days to maturity from seeding: 80-114 days (Average 93 days)

iv. Yield (kg/ha):877-1405 (Average 1021)

v. No. of seeds/siliqua: 10-16 (Average 13)

vi. No. of siliqua/plant: 58-223 (Average 107)

vii. 1000-seed weight:2.1-5 g (Average 2.95 g)

b. Quality of economically important parts of the crop:

i. Physical quality (size, shape, colour etc): Light purple round seed

ii. Processing: Oil extraction

iii. Organoleptic test (taste, aroma/flavour, etc): Good flavor

iv. Other specific qualities (if any): High oil content (46 %)

Other characteristics (threshing, storability, transportability, market potential): Oil mill/farmers prefer this variety due to high oil recovery.

Morphological description for varietal:

Medium plant height, dense siliquae and siliqua are arranged with narrow angle. Sterile siliquae is less in shoot tips.

Identifying characteristics of a crop variety for its authenticity:

Medium plant height, branching started from the base, dense siliquae, siliqua arranged in narrow angle.

Recommendation Domain

Central, western and Mid-western Terai/Inner Terai and Mi-Hills (around 600m)

- Agro-ecological zone: Terai, Inner Terai and Mid-Hills
- Moisture regime: Irrigated, partially irrigated.
- Growing season: Winter season, timely/early planting especially for maize-toria-wheat system

Package and Practices of The Variety

- Seed sowing: Winter season (Asoj), early/timely sowing to escape insect pests infestation and higher yield.
- Seed rate: 6-7 kg/ha for sole crop and 2-3 kg/ha for mix crops.
- Method of sowing: Line sowing 30 cm apart and thinning 10 cm apart at 15 DAS
- Fertiliser rate: 80 :40 :20 NPK kg/ha
- Weeding: Once (25 DAS)
- Irrigation: Before flowering and pod filling stage, if available
- Plant protection: Alternaria blight: Dithane M 45 @ 2.5 g/L of water at 45 and 60 DAS
- Early (September) planting escape the disease incidence

Reason for Varieties Release

- ❖ High oil recovery
- ❖ High on farmers preference
- ❖ Wider adaptability and stability
- ❖ Low incidence of insect pests

Conclusion

Although Nepal is an agricultural country and agriculture is the mainstay for the economy of the country. However, due to the lack of technical manpower and enough investment in the agriculture research, Nepal is still backward in the agriculture and research and development. It even has lack of echnical man power and highly molecular lab to create the diversification in the genotypes. For the date, screening of the exotic genotypes is the best way for instant to identify the promising variety. In case of rapeseed, Out of I4 genotypes, ICT 2001-35 was identified as high yielding, high amount of oil content, wider adaptability and stable rapeseed among the genotypes. It was released by the Nepal seed board as a variety with a name of "Nawalpur tori -4" . Hope this variety will be popular among the rape seed growing farmer of Nepal and will contribute in the oil demand of Nepal in some extent.

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References

Al-Shehbaz IA, Beilstein MA and Kellogg EA. (2006) Systematics and phylogeny of the Brassicaceae (Cruciferae): an overview. Plant Systematics and Evolution. **259**(2): 89-120. https://doi.org/10.1007/s00606-006-0415-z

Chalhoub B, Denoeud F, Liu S, Parkin IA, Tang H, Wang X, Chiquet J, Belcram H, Tong C, Samans B and Corréa M (2014) Early allopolyploid evolution in the post-Neolithic Brassica napus oilseed genome. *Science* **345**(6199): 950-953. DOI: 10.1126/science.1253435

Confortin TC, Todero I, Luft L, Ugalde GA, Mazutti MA, Oliveira ZB, Bottega EL, Knies AE, Zabot GL and Tres MV (2019) Oil yields, protein contents, and cost of manufacturing of oil obtained from different hybrids and sowing dates of canola. *Journal of Environmental Chemical Engineering* **7**(2):102972. https://doi.org/10.1016/j.jece.2019.102972

Daun JK, Eskin MN and Hickling D (2015) Canola: chemistry, production, processing, and utilization. Elsevier; https://doi.org/10.1016/B978-0-9818936-5-5.50005-X

Ghimire TB, Chaudhary RN and Ray SP (2001) Quantification of yield limiting constraints in toria production. *Annual report, NORP 2000*: 61.

Meyer RS and Purugganan MD (2013) Evolution of crop species: genetics of domestication and diversification. Nature reviews genetics. **14**(12): 840-852. https://doi.org/10.1038/nrg3605

Peterson CL, Reece DL, Hammond BL, Thompson J and Beck SM (1997) Processing, characterization, and performance of eight fuels from lipids. *Applied Engineering in Agriculture* **13**(1): 71-79. doi: 10.13031/2013.21578)

Zentková I and Cvengrošová E (2013) The utilization of rapeseed for biofuels production in the EU. *Visegrad Journal on Bioeconomy and Sustainable Development* **2**(1): 11-14. DOI: https://doi.org/10.2478/vjbsd-2013-0002