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Evaluation of Turkish grass pea (*Lathyrus sativus* L.) collections for its agronomic characters with a special reference to ODAP content

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ABSTRACT

Fifty-two grass pea (*Lathyrus sativus* L.) genotypes were investigated in terms of agronomic performance, protein and ODAP (b-N-oxalyl-l-diamino-propionic acid) content under semi-arid conditions of Inner Anatolia during 2013 and 2014. High variation was observed among genotypes, especially for seed yield and ODAP content. Seed yield ranged from 1142.4 kg/ha up to 2046.4 kg/ha with a mean of 1521.1 kg/ha, ODAP content in seed varied from 2.62 mg/g up to 5.59 mg/g with an average of 3.85 mg per g and seed protein ratio was between 26.77% and 30.20% over the genotypes and years. A significant and negative correlation of ODAP was noted with seed yield (r = -0.38). This association is very encouraging for breeders to improve new varieties having high seed yield and low ODAP content. The results from this study indicated that ten grass pea genotypes consisting two ICARDA lines and eight landraces from Turkey recorded superior with low ODAP content and and high seed yield (changed between 1680.9 kg/ha and 2046.4 kg/ha). So, these may be potential candidates for new varieties.

Key words: Grass pea, *Lathyrus sativus*, ODAP, Protein, Variation.

INTRODUCTION

Lathyrus (*Fabaceae*) is a large genus with ~ 160 species. However, only a few species have an economical importance as food, feed and forage (Campbell, 1997). Grass pea (*Lathyrus sativus* L), is the most important species of *lathyrus* genus as a source of food (Jackson and Yunus, 1984) with potential advantages such as drought tolerance, high protein content in seeds (Grela *et al.*, 2010), higher pest and disease resistance (Tiwari and Campbell, 1996). Recent years, grass pea has become the focus of attention in drought-prone and marginal areas in the world with an acceptable yield even under adverse climatic and soil conditions. (Vaz patto *et al.*, 2006). Despite these desirable properties, long term over-consumption of grass pea seeds as staple food can result in neurological disorder such as 'lathyrism' (Lambein and Kuo, 1997) characterized by spastic paralysis and weakness of the leg of human and animals (Rao *et al.*, 1964). Lathyrism is caused by ODAP (b-N-oxalyl-l-diamino-propionic acid), a neurotoxic non protein amino acid (Singh and Rao, 2013). ODAP content of grass pea seed shows a variation from 0.04 up to 1.6% in seed depending on genotype and environment (Hanbury *et al.*, 1999: Tamburino *et al.*, 2012), and less than 0.2% is critical value (Abd El-Moneim *et al.*, 2010). This toxic content is the main reason that limited the utilization of grass pea (Sharma-*et al.*, 2000). Thus, low ODAP, high protein and high seed yield are main concerns in grass pea breeding (Hanbury *et al.*, 2000).

Grass pea, is known in Turkish as "murdumuk" remained a marginal crop and is grown as forage, feed and rarely as food in Turkey to meet household consumption (Basaran *et al.*, 2013). Since 2000, Turkish government encouraged area under forage crops to meet the growing demands. It is cultivated over an area of about 24300 ha (1270 ha for seed and 23030 ha for forage) (TUIK, 2014) in Turkey. Grass pea can be grown for herbage in coastal areas, but seed production is more suitable in the arid inner regions of Turkey (Firincioglu *et al.*, 2004). Drought tolerance, low input requirement, high grain yield, nutritive value and pod shattering resistance nature of the grass pea genotypes makes it an ideal crop and hence preferred by farmers. Despite this, grass pea has still received little attention and landraces are rarely cultivated even today (Basaran and Acar, 2013).

Grass pea cultivation can be improved by replacement of landraces with better yielding and low ODAP content varieties. So, in the present study, fifty-two grass pea genotypes were investigated for some morphological and biochemical variation under semi-arid conditions to determine superior genotypes with high seed yield and low ODAP content to be candidate for new varieties.

MATERIALS AND METHODS

Fifty-two grass pea genotypes that include one registered variety, three ICARDA lines and forty-eight Turkish landraces (Table 1) were investigated in the Yozgat conditions (located semi-arid parts of Inner Anatolia) during

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Table 1: Origin of the grass pea genotypes under investigation.

Landraces/lines	Province	Town	Village	Altitude (m)
Gurbuz	Registered variety			
Sel 560	ICARDA line			
Sel 564	ICARDA line			
Sel 566	ICARDA line			
201	Adiyaman	Merkez	Dardogan	825
1501	Burdur	Bucak	Kizilkaya	787
1502		Yesilova	Harmanli	1093
1503		Bucak	Kizilkaya	787
1601	Bursa	Harmancik	Dogancilar	781
1602		Harmancik	Dogancilar	781
1603		Harmancik	Demirciler	719
1604		Local seed market		
1801	Cankiri	Merkez	Yukaripelitozu	768
1802		Merkez	Yukaripelitozu	768
1803		Eldivan	Elmaci	957
2001	Denizli	Merkez	Uzunpinar	1148
2002		Civril	Cabar	1013
2003		Tavas	Ulukent	934
2006		Cal	Baklancakirlar	886
2007		Acipayam	Alaaddin	887
2008		Merkez	Not known	
2009		Kirca	Not known	
2401	Elazig	Merkez	Uzuntarla	995
2402		Merkez	Acipayam	987
2404		Local seed market		
4301	Kutahya	Domanic	Merkez	
4401	Malatya	Darende	Yenikoy	1600
4402		Darende	Yenikoy	1600
4403		Darende	Basdirek	1445
4404		Local seed market		
5001	Nevsehir	Kozakli	Kalecik	1120
5002		Hacibektas	Sadik	1159
5003		Gulsehir	Sahinler	880
5004		Gulsehir	Hacihalilli	1000
5005		Acigol	Cullar	1086
5006		Acigol	Tatlarin	1113
5501	Samsun	Kavak	Degirmenci	600
6401	Usak	Sivasli	Hacim	938
6402		Merkez	Kasbelen	960
6403		Merkez	Kasbelen	960
6404		Merkez	Kasbelen	960
6405		Ulubey	Inay	743
6406		Ulubey	Inay	743
6407		Ulubey	Inay	743
6408		Ulubey	Kisla	800
6409		Ulubey	Kisla	800
6410		Ulubey	Kisla	800
6411		Ulubey	Karacaahmet	780
6412		Merkez	Ilyasli	770
6413		Merkez	Ilyasli	770
6415		Merkez	Ilyasli	770
6416		Merkez	Ilyasli	770

2013 and 2014. Sowing was done by using trial plot seeder with the 50 seed/m^2 rate on 14.4 m^2 plots. Each plot consisted of four rows with 6 m long at 40 cm spacing. Experiment was laid out in a randomized block design with three replications. General properties of the experimental soil are given in Table 2. The prevailing temperature and the rainfall recorded in the experimental field is presented in figure 1. The growing season includes the period from March to June. However climatic conditions were given for January-June period considering residual effect of rainfall in the soil. Seed yield, thousand seed weight, plant height, days to flowering and days to maturity were determined according to IPGRI (2000). Total nitrogen was determined by the Kjeldahl method and protein ratio was estimated using a conversion factor of 6.25.

Quantitative estimation of ODAP was done by the modified method of Rao (1978). Regent; O-phthalaldehyde (OPT) reagent was prepared by mixing 100 mg OPT (dissolved in 0.2 ml mercaptoethanol), 1 ml of ethanol (95%) and 100 ml borate buffer (152.7 g potassium tetraborate and 500 ml distilled water). Diaminopropionic acid (DAP) was used as a standard. All the chemicals are analytical regent.

Table 2: General properties of soil in the experimental location.

Features	Value	Classify
Texture (%)	54.78	Clay-loam
pH	8.20	Alkaline
$CaCO_3$ (%)	7.93	Medium
Salt (%)	0.018	Low
P_2O_5 (kg/ha)	86.2	Medium
K_2O (kg/ha)	484.7	High
Organic matter (%)	1.91	Low

Extraction; 20 mg finely powdered seed sample was taken in test tube and 2 ml distilled water was added to it. The tubes were kept in boiling water and cooled to room temperature and then centrifuged. 100 µl supernatant + 0.2 ml 3 N KOH were placed in tube and kept in boiling water for 30 minutes. After hydrolysis, 0.7 ml of water and 2 ml OPT regent was added to tube and allowed remain for 15 minutes for yellow colour development. Finally, the yellow color was measured in spectrophotometer (Perkinelmer Lambda 25) at 425 nm.

The mean data on the traits under investigation are presented. Correlation among the five quantitative traits on seed yield and PCA analysis was performed by using SPSS 13.0 Package program.

RESULTS AND DISCUSSIONS

The variation among the investigated grass pea genotypes for agronomic and biochemical traits are given for two different years individually (Tables 3 and 4) and an average of both the seasons (Table 5). High variation was determined among genotypes especially for seed yield, protein yield and ODAP content with substantial effect. In 2014, seed yield and days to maturation were higher while ODAP content was lower. This can be attributed to the higher rainfall received during 2014 compared to 2013 season, especially on May (Figure 1) that plant growth is very fast this month. This indicated that grass pea gave good response under favoruable weather conditions. Considering the average performance across seasons, seed yield ranged from 1142.4 kg/ha up to 2046.4 kg/ha with a mean of 1521.1 kg/ha among genotypes (Table 5). The highest seed yield was observed in the landrace 2006. All the genotypes recorded higher seed yield in 2014 due to better condition. Thousand

Table 3: Morphological and biochemical variation of grass pea genotypes during 2013.

Traits	N	Min.	Max.	Mean	CV (%)
Seed yield (kg/ha)	52	499.3	2133.0	1214.6	25.19
Protein ratio (%)	52	26.08	30.10	27.94	3.83
Protein yield (kg/ha)	52	138.1	567.4	338.4	24.05
Thousand seed weight (g)	52	112.50	154.85	131.94	8.41
Plant height (cm)	52	25.00	47.35	37.32	12.59
Days to flowering (day)	52	44.67	53.67	50.34	2.38
Days to maturation (day)	52	86.00	93.33	87.92	1.38
ODAP (mg/g)	52	3.25	7.31	4.97	25.35

Table 4: Morphological and chemical variation of grass pea genotypes during 2014.

Traits	N	Min.	Max.	Mean	CV (%)
Seed yield (kg/ha)	52	1239.6	2707.9	1827.6	17.04
Protein ratio (%)	52	26.09	31.52	28.53	4.84
Protein yield (kg/ha)	52	335.6	800.3	521.3	17.72
Thousand seed weight (g)	52	107.25	161.33	131.37	9.92
Plant height (cm)	52	30.30	48.15	38.06	10.61
Days to flowering (days)	52	50.50	58.00	53.61	2.89
Days to maturation (days)	52	107.50	110.50	108.48	0.63
ODAP (mg/g)	52	1.68	4.49	2.73	21.25

Table 5. Morphological and chemical variation of grass pea genotypes in combined years.

Traits	N	Min.	Max.	Mean	CV (%)
Seed yield (kg/ha)	52	1142.4	2046.4	1521.1	13.58
Protein ratio (%)	52	26.77	30.20	28.24	3.08
Protein yield (kg/ha)	52	306.9	588.9	429.4	13.67
Thousand seed weight (g)	52	113.03	154.45	129.73	7.63
Plant height (cm)	52	30.98	45.63	37.69	7.91
Days to flowering (day)	52	47.67	55.83	51.98	2.35
Days to maturation (day)	52	97.25	101.42	98.20	0.70
ODAP (mg/g)	52	2.62	5.59	3.85	19.74

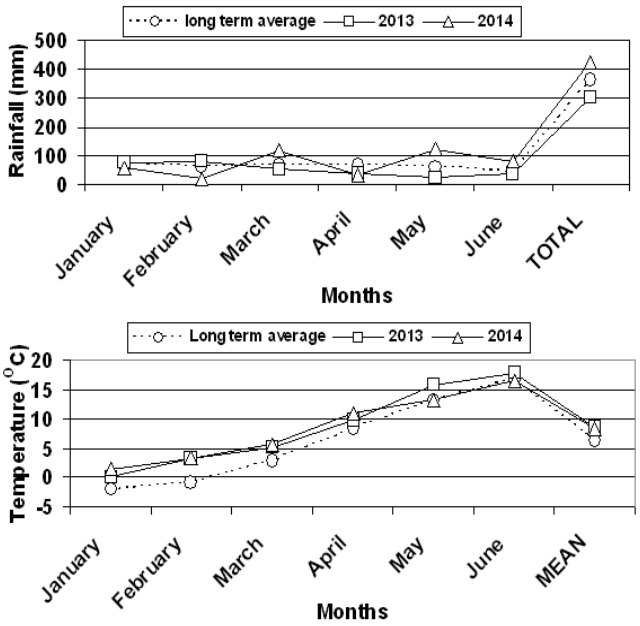


Fig 1: Monthly total rainfall and average temperature of the experimental area during 2013-2014 seasons.

seed weight varied from 113.03 g (2013) to 154.45 g (2014) with an average of 129.73 g (Table 5). Jackson and Yunus (1984) reported variation of high magnitude in grass pea genotypes for different morphological traits and a similar report on seed yield by Kumar and Dubey, (2001).

Plant height ranged between 30.98 cm 45.63 cm across the seasons and averaged 37.69 cm (Table 5). The observed variation for plant height was medium (CV=7.95%) among genotypes and this can be associated with low rainfall received during the month of April (Figure 1) that limits plant growth by causing stress and induces early flowering. Earlier, a strong correlation between plant height and rainfall has been reported in grass pea genotypes (Grela *et al*. 2010). Similarly, the closer values for beginning of flowering time between years (50.34 days and 53.61 days, respectively) can be explained by drought conditins observed in April. However, compared to 2013, seed maturation was delayed by about 10 days in 2014 due to the higher rainfall received during May.

In comparison with seed yield and and ODAP content, protein ratio showed lesser variation in two years individually (Table 3 and 4) and also when averaged across both years (Table 5). The genotypes exhibited a variation ranging from 26.77% (landrace 1802) to 30.20% (landrace 6416). It is observed that genotypes affected by year at different levels in terms of protein when examined separately and, the highest protein content was determined in landrace 2002 (30.10%) in 2013 and in landrace 6416 (31.52%) in 2014 (Figure 2). Protein content of grass pea could reach up to 34% (Rosa *et al.*, 2000). Grella *et al*. (2010) investigated thirty-one European accessions of grass pea and reported that protein ratio varied between 22.87 and 31.29%. The protein content observed in the present study was found to agree with the earlier findings. There is a clear variation among genotypes in terms of protein yield changing from 306.9 kg/ha (landrace 1401) to 588.9 kg/ha (landrace 2006) based on average performance of two years. As expected high yielding genotypes were found to be superior for protein yield also.

Average ODAP content varied from 2.62 mg/g up to 5.59 mg/g with average of 3.85 mg/g (Table 5) among the genotypes across two years. The landrace 6403 recorded the lowest ODAP content while the maximum was observed in the landraces 6407 and 4401. ODAP showed the highest variation in both years (CV= 25.35% and 21.25%, respectively) and combined years (CV= 19.74%) (Tables 3, 4 and 5). The high CV values showed that there might be a large genetic difference among the genotypes. The success of plant breeding highly depends on the nature and extent of genetic variation (Kumar and Dubey 2001). However, ODAP content in the present genotypes is relatively high compared to 2 mg/g content reported as critical value by Abd El-Moneim *et al.* (2010). Low ODAP content is one of the main targets of the grass pea breeding besides high grain yield and protein content (Tadesse and Bekele, 2003). ODAP is mainly controlled by genetic factors and lesser by environment (Hanbury *et al.*, 1999). Among abiotic factors, particularly drought results in increased ODAP content (Lambein *et al.*, 1994, Cocks *et al.*, 2000). In our study, ODAP content of grass pea seed exhibited a different trend

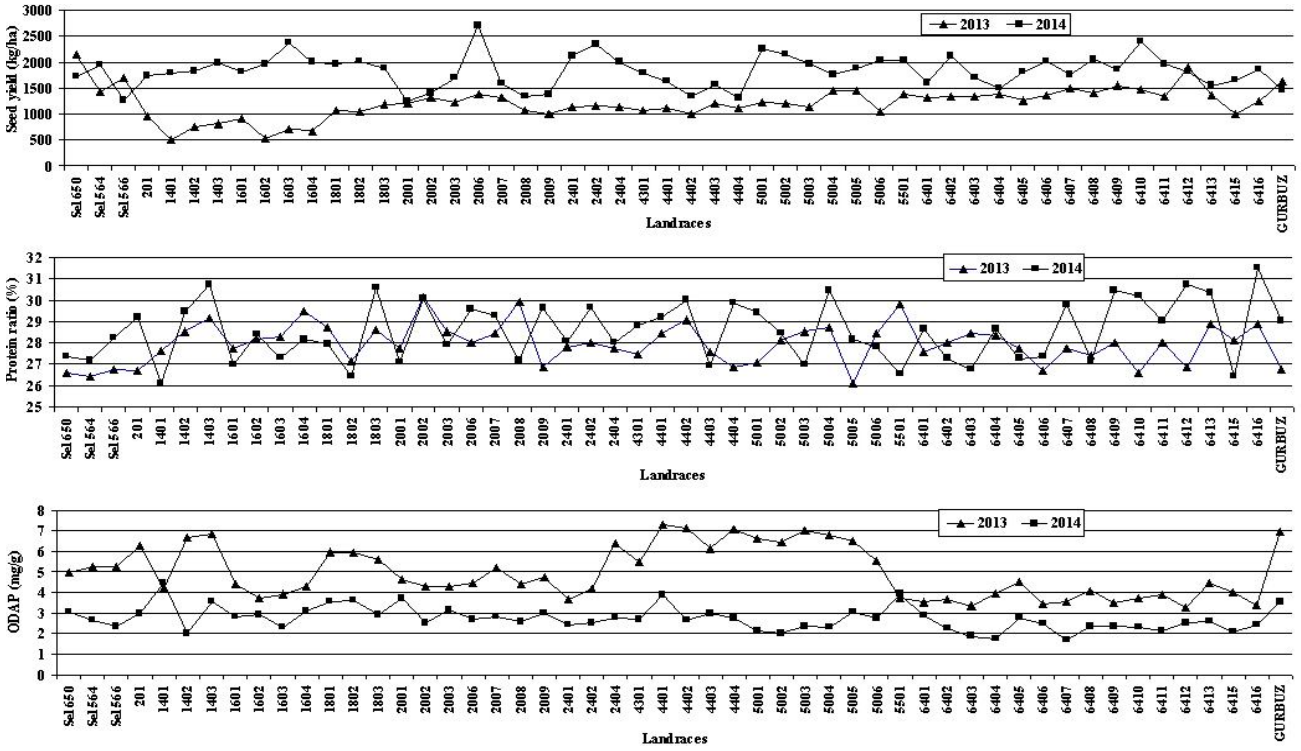


Fig 2: Variability for seed yield, protein ratio and ODAP content in 52 grass pea genotypes between 2013 and 2014 years

in two seasons (Figure 2) and it increased two folds during 2013 which is the drought year (Table 3 and 4). ODAP content of grass pea genotypes examined in the present study is reported between 1.40 and 3.05 mg/g (Basaran *et al.*, 2013), between 1.0 and 8.7 mg/g (Onar *et al.*, 2014), between 1.35 and 3.86 mg/g (Basaran *et al.*, 2011). These differences indicate that there is a high level of environmental impact on ODAP contrary to Hanbury *et al.* (1999) who reported high genetic affect on ODAP.

Significant correlations between the investigated traits are presented given in Table 6. A significant positive correlation ($r = 0.97$, $p<0.01$) was observed between seed yield and protein yield. This could be attributed to low variation between genotypes in terms of protein ratio. Significant and negative correlation of ODAP was noted with seed yield (r=-0.38), protein yield (r=-0.41) and days to flowering (r=-0.44). These results indicated that high yielding and late flowering genotypes were also low ODAP content. Likewise a negative correlation was reported between ODAP and seed yield by Tadesse and Bekele (2003) and Basaran *et al.* (2013). However positive association between ODAP and seed yield was reported by Hanbury *et al.* (1999). In the present study, significant and positive correlation of ODAP with seed yield indicates the potential for simultaneous improvement of yield, ODAP and protein content of the grass pea genotypes under study.

To identify the superior grass pea genotypes, principle component analysis was performed based on seed yield and ODAP content (Figure 3). The distribution of genotypes on the scatter plot was relatively clear due to negative correlation between seed yield and ODAP and, the best genotypes with high yield and relatively low ODAP

Table 6: Correlations between the seven different agronomically important traits in grass pea genotypes.

Traits	SY	PR	PY	TSW	PH	DF	DM	ODAP
Seed yield	1							
Protein ratio	-0.08	1						
Protein yield	0.97**	0.14	1					
TSW	-0.05	-0.17	-0.10	1				
Plant height	0.34**	-0.33**	0.26*	0.20	1			
Days to flowering	0.25*	-0.05	0.24*	-0.32**	0.01	1		
Days to maturation	0.13	-0.07	0.10	-0.19	-0.05	0.48**	1	
ODAP	-0.38**	-0.14	-0.41**	0.32**	0.13	-0.44**	-0.09	1

** P<0.01, * P<0.05)

SY: Seed Yield, PR: Protein Ratio, PY: Protein Yield, TSW: Thousand Seed Weight, PH: Plant Height, DF: Days to flowering, DM: Days to maturation.

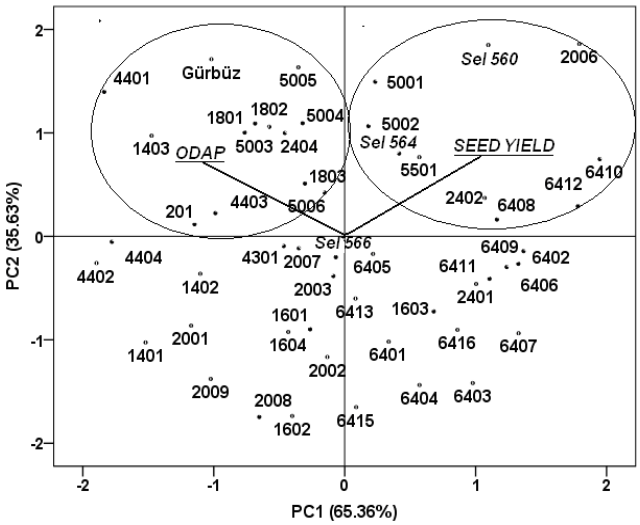


Fig 3: Distribution of the grass pea genotypes on PCA biplot based on seed yield and ODAP content.

content grouped together. Based on combined performance in two seasons, ten genotypes consisting two ICARDA lines and eight landraces (2006, 6410, Sel 564, 6412, 2402, 5001, 6408, 5501, Sel 560, 5002), were determined as promising for future breeding on grass pea improvement. The variation among these promising genotypes was between 1680.9 kg/ha (landrace 5002) and 2046.4 kg/ha (landrace 2006) for seed yield and was between 2.89 mg/g (landrace 6412) and 4.37 mg/g (landrace 5001) for ODAP content. ODAP content in high yielding genotype (landraces 2006) was 3.58 mg/g. Landrace 6412 having the lowest ODAP content (2.89 mg/g) had 1844.0 kg/ha seed yield. Registered variety (Gurbuz) was not located in this group with 1559.2 kg/ha seed yield and 5.23 mg/g ODAP content. Therefore selected promising genotypes may be potential candidates for new varieties suitable for semi-arid conditions.

Grass pea is an important crop especially for drought and marginal lands. So it is valuable crop for agricultural sustainability. In addition its importance may increase further especially under global climate change scenarios. Recently, the interest in grass pea cultivation as a forage crop is increasing in Turkey, although its cultivation is still very uncommon. Compared to other legumes, grass pea has been seriously neglected and only five varieties have been registered in the country until now. To expand grass pea cultivation there is a need for new varieties with high yield and low ODAP content. Especially variation for seed yield and ODAP content observed in this study provides ample scope for future breeding initiatives in grass pea. However, ODAP content of the investigated genotypes was and greatly influenced by drought. The negative correlation observed between ODAP and seed yield indicated that high yield in certain environment may be a crucial factor for the low levels of ODAP in the grass pea genotypes. Hence, the results of the present study suggested the genotype selection in grass pea should be made specific to a particular environment prevailing in an ecosystem.

REFERENCES

Abd El-Moneim, A.M., Nakkoul, H., Masri, S. and Ryan, J. (2010). Implications of zinc fertilization for ameliorating toxicity (Neurotoxin) in Grasspea (*Lathyrus sativus*). *J. Agr. Sci. Tech.* **12:** 69-78.

Basaran, U. and Acar, Z. (2013). Recent and historical status of grass pea (*Lathyrus sativus* L.) in Turkey. *Cassava Cyanide Diseases Network* (CCDN). **22:** 8-10.

Basaran, U, Asci Onal, O., Mut, H., Acar, Z. and Ayan, I. (2011). Some quality traits and neurotoxin ß-N-oxalyl-L- a, ß-diaminopropionic acid (ß-ODAP) contents of Lathyrus sp. cultivated in Turkey. *African Journal of Biotechnology*. **10:** 4072-4078.

Basaran, U., Acar, Z., Karacan, M. and Onar, A.N. (2013). Variation and correlation of morpho-agronomic traits and biochemical contents (protein and ß -ODAP) in Turkish grass pea (*Lathyrus sativus* L.) landraces. *Turkish Journal of Field Crops*. **18:** 166-173.

Campbell, C.G. (1997). Grasspea (*Lathyrus sativus* L.) Promoting the Conservation and Use of Underutilized and Neglected crops. Institute of Plant Genetics and Crop Plant Research, Gatersleben/International Plant Genetic Resources Institute, Rome.

Cocks, P., Siddique, K. and Hanbury, C. (2000). Lathyrus. A New Grain Legume: A report for the rural industries research and development corporation. Rural Industries Research and Development Corporation.

Firincioglu, H.K., Unal, S. and Ozpinar, H. (2004). Grass pea (*Lathyrus Sativus* L.) as a feed crop in mixed farming systems in Turkey. *Journal of Field Crops Central Research Institute*. **13:** 29-36.

Grela, E.R., Rybinski, W., Klebaniuk, R. and Mantras, J. (2010). Morphological characteristics of some accessions of grass pea (*Lathyrus sativus* L.) grown in Europe and nutritional traits of their seeds. *Genetic Resources and Crop Evolution*. **57:** 693-701.

Hanbury, C.D., Siddique, K.H.M., Galwey, N.W. and Cocks, P.S. (1999). Genotype-environment interaction for seed yield and ODAP concentration of *Lathyrus sativus* L. and *L. cicera* L. in Mediterranean-type Environments. *Euphytica*. **110:** 445–460.

Hanbury, C.D., White, C.L., Mullan, B.P. and Siddique, K.H.M. (2000). A review of the potential of *Lathyrus sativus* L. and *L. cicera* L. grain for use as animal feed. *Anim Feed Technology*. **87:** 1– 27.

IPGRI, (2000). Descriptors for Lathyrus ssp. Int. Plant Genetic Resources Inst. Press, Rome, Italy.

Jackson, M.T. and Yunus, A.G. (1984). Variation in the grass pea (*Lathyrus sativus* L.) and wild Species. *Euphytica*. **33:** 549–559.

Kumar, S. And Dubey, D.K. (2001). Variability, heritability and correlation studies in grass pea (*Lathyrus sativus* L.) *Lathyrus Lathyrism Newsletter*. **2:** 79-81.

Lambein, F. and Kuo, Y.H. (1997). Factors affecting human susceptibility to neurolathyrism. In: Tekle Haimanot, R., Lambein, F. (Eds.), *Lathyrus* and Lathyrism, a Decade of Progress. University of Ghent, Belgium, pp. 9–13.

Lambein F., Haque, R., Khan, J.K., Kebede, N. and Kuo, Y.H. (1994). From soil to brain: zinc deficiency increases the neurotoxicity of *Lathyrus sativus* and may affect the susceptibility for the motorneurone disease neurolathyrism. *Toxicon*. **32:** 461–466.

Onar, A.N., Erdogan, B.Y., Ayan, I. and Acar, Z. (2014). Homoarginine, b-ODAP, and asparagine contents of grass pea landraces cultivated in Turkey. *Food Chemistry*. **143:** 277–281.

Rao, S.L.N. (1978). A sensitive and specific colorimetric method for determination of a,b-diaminopropionic acid and *Lathyrus sativus* neurotoxin. *Analytical Biochemistry*. **86:** 386–396.

Rao, S.L.N., Adiga, P.R. and Sharma, P.S. (1964). Isolation and characterization of betha-oxalyl-L-diaminopropanoic acid: A neurothoxin fom the seeds of *Lathyrus sativus*. *Biochem.* **3:** 432–436.

Rosa M.J., Ferreira, R.B. and Teixeira, A.M. (2000). Storage proteins from *Lathyrus sativus* Seeds. *J. Agric.Food Chem*. **48:** 5432–5439.

Sharma, R.N., Chitale, M.W., Ganvir, G.B., Geda, A.K. and Pandey, R.L. (2000). Observations on the development of selection criterion for high yield and low neurotoxin in grass pea based on genetic resources. *Lathyrus Lathyrism Newsletter*. **1:** 15–16.

Singh, S.S. and Rao, S.L.N. (2013). Lessons from neurolathyrism: A disease of the past and the future of *Lathyrus sativus* (Khesari dal). *Indian J Med Res*. **138:** 32–37.

Tadesse, W. and Bekele, E. (2003). Variation and association of morphological and biochemical characters in grass pea (*Lathyrus sativus* L.). *Euphytica*. **130:** 315-324.

Tamburino, R., Guida, V., Pacifico, S., Rocco, M., Zarelli, A., Parente, A. and Di Maro, A. (2012). Nutritional values and radical scavenging capacities of grass pea (*Lathyrus sativus* L.) seeds in Valle Agricola district, Italy. *AJCS*. **6:** 149-156.

Tiwari, K.R and Campbell, C.G. (1996). Inheritance of neurotoxin (ODAP) content, flower and seed coat colour in grass pea (*Lathyrus sativus* L.). *Euphytica*. **91:** 195–203.

TUIK, (2014). Turkish Statistical Institute, Crop porduction statistics, Available: http://www.turkstat.gov.tr/PreTablo.do ?alt_id=1001

Vaz-Patto, M.C., Skiba, B., Pang, E.C.K., Ochatt, S.J., Lambein, F. and Rubiales, D. (2006). *Lathyrus* improvement for resistance against biotic and abiotic stresses: From classical breeding to marker assisted selection. *Euphytica*. **147:** 133-147.