ACTA SCIENTIARUM POLONORUM
Acta Sci. Pol. Hortorum Cultus, 16(5) 2017, 117–124
www.acta.media.pl ISSN 1644-0692 DOI: 10.24326/asphc.2017.5.12

ORIGINAL PAPER

Accepted: 31.05.2017

INTRODUCTION OF ENDEMIC *Allium tuncelianum* KOLLMAN FROM HOT AND TEMPERATE CLIMATE TO SEMI-ARID CLIMATIC CONDITIONS

Suleyman Kizil[1]✉, Khalid Mahmood Khawar[2]

[1] Dicle University, Faculty of Agriculture, Department of Field Crops, 21280 Diyarbakir, Turkey

[2] Ankara University, Faculty of Agriculture, Department of Field Crops, 06100 Ankara, Turkey

ABSTRACT

Allium tuncelianum (Tunceli garlic) is a single cloved important threatened endemic geophyte of high commercial importance that grows scattered on hot temperate mountains under oak trees in the eastern Turkish province of Tunceli. Tunceli garlic is used diversely in salads, foods and in pharmaceutical industry. They also offer a rich choice for their use in rock gardens and landscaping. There is need to develop appropriate agronomic practices for its propagation outside its habitat. In line with this objective, the study optimized planting time (1st September, 15th September and 1st October) of *A. tuncelianum* on mild alkaline soils under semi-arid climatic conditions of Diyarbakir, Turkey. The results of the study showed positive gain in morphological characteristics such that bulb diameter of the plants changed between 3.43 to 4.60 cm, bulb circumference ranged 14.4 to 16.1 cm and bulb weight had a range of 35.9 and 46.3 g. These results underscore positive effects of early and mid September plantings of Tunceli garlic outside its habitat under semi-arid conditions for economic production with early harvest.

Key words: Tunceli garlic, bulb production, cultivation, planting time

INTRODUCTION

The genus Allium includes 600–750 species, most of which; including onion and garlic, are cultivated and consumed indigenously or are used as hardy perennial ornamentals plants since centuries [Friesen et al. 2006, Block 2010]. Most of them have light to strong pungent smell that is off putting due to presence of sulphur containing compounds.

The garlic is the second most important *Allium* species grown worldwide as an important spice and medicinal plant; due to its broad antibiotic activities against (gram positive and negative bacteria). Use of garlic has been reported for providing resistance against cardiovascular problems since centuries and has been the best investigated among other characteristics of all plant species [Stavelikova 2008].

Wild relatives of common garlic could serve as good source of germplasm for development of new cultivars and should be cared for cultivation in regions other than their habitats to achieve superior resistance/tolerance to pests and disease [Kamenetsky 2006]. Single cloved structured *Allium tuncelianum*, is an endemic edible vulnerable threatened plant

✉ suleymankizil@gmail.com

species among Turkish flora of southeast and east Anatolia [Etoh and Simon 2002, Kizil et al. 2012]. It grows scattered at Munzur mountainous range and Ovacik district of Tunceli province [Ipek et al. 2008, Kizil et al. 2014]. Tunceli garlic is usually collected from the wild around August and sometimes over collected that threatens the plant with extinction. It is widely exported to metropolitan cities in Turkey for culinary uses as table vegetable, salad, and for their use in local pharmacopeia. They also offer a rich choice for their use in rock gardens and landscaping with their attractive white to pink inflorescence that yield seeds.

It has very few agronomic studies that give very insufficient information about agronomy of the plant [Kizil et al. 2012]. There is need to carry out more studies to know more about the agronomic characteristics and behaviour of the plant outside its habitat.

The aim of this study was to measure, compare and optimise most suitable planting time for Tunceli garlic under semi-arid climatic conditions of Diyarbakir; which has distinct differences in climate compared to its natural habitat with hot temperate climatic conditions. Determination of the appropriate planting date for Tunceli garlics outside natural habitat will help to conserve it. Moreover, it will also help and improve local farmers economically; if introduced as economic crop under state patronage. Early or late sowing of plants could have adverse effects on quality and quantity of yield. Appropriate sowing date could vary from plant to plant under different growing conditions.

MATERIALS AND METHODS

Field studies were conducted under Diyarbakır ecological conditions at the Department of field Crops, Faculty of Agriculture (latitude 37°53'N and longitude 40°16'E, 680 m a.s.l.), Dicle University during 2011–2012 and 2012–2013 growing seasons. The experimental area is alluvial plain lying very close to river Tigris with clay encompassing dominant structure of the soil. It had 0.41% organic matter, 1.7 kg ha^{-1} phosphorus (P_2O_5), 79.8 kg ha^{-1} potassium (K_2O), pH of 8.08 (alkaline soil) and electrical conductivity of 0.026 (mm hos cm^{-1}). Meteorological data for the growing seasons showed long-term annual mean temperature of 14.8°C and total precipitation of 495.2 mm for September and July. The average temperature, humidity ratios and the amount of total precipitation values of 2011–2012 and 2012–2013 for the September–July period were 13.9°C and 15.6°C; 53.8% and 74.6%; and 406.7 mm and 680.6 mm respectively (State Meteorology Institute, Diyarbakir, Turkey).

Allium tuncelianum bulbs used in the study were obtained from local traders at Ovacik district of Tunceli province (39°16'N; 39°26'E; 1050 m a.s.l.), Turkey (fig. 1) during the month of August 2011 and were freshly harvested; that were previously collected from wild flora by locals. These bulbs had mean bulb diameter of 3.28 cm, mean bulb weight of 17 g and mean bulb circumference of 11.2 cm (mean of 20 bulbs).

Fig. 1. Tunceli garlic growing at its habitat near Ovacik (Tunceli) under natural conditions on rocky slopes

Experimental fields were watered before planting. Planting was done with row spacing of 70 cm and plant spacing of 20 cm. The experimental design was a randomized complete block design with three replications for each experimental year with three plantings each done on 1st September (early September), 15th September (mid-September) and 1st October (early October) with 48 bulbs in each plot. Plot size was kept 8.4 m^2 (2.8 × 3 m) in each of the experiment. Planted bulbs had diameter of 2 to 3 cm and

were hand planted at a depth of 5–8 cm in the soil. The plots were weeded as and when required. The plots were harvested manually on 5th June, 2012 for the first year and 18th May, 2013 for the second year. Plant height, plant stem diameter, leaf length, leaf width, leaf sheath length, flower head diameter, bulb diameter, bulb circumference, bulb weight and induction of number of bulbils per bulb were investigated.

Morphological data obtained in the study were analysed statistically, using MSTAT-C (Michigan State University) computer program, and the means were grouped, using LSD test at 0.05 level of significance.

RESULTS AND DISCUSSION

Analysis of variance results showed that plant height, leaf length and flower head diameter were not significantly affected by planting times (planting dates) and years; while plant stem diameter, leaf width, bulb weight and number of bulbils per bulb were significantly ($p \leq 0.05$) affected by years (climatic changes). The leaf width, bulb diameter, bulb circumference and bulb weight were significantly ($p \leq 0.05$) affected by the planting times (tab. 1) without having any significant effect due to years or climatic changes.

Planting times did not significantly influence plant height ($p \leq 0.05$), first year mean plant height (112.1 cm) was lower compared to plant height (120.2 cm) obtained during second year (tab. 2). Comparing differences among planting times, the minimum plant height was noted on early September and the maximum plant height was noted on mid September planted cloves. The difference in plant height on early October planting was statistically similar to that of mid September planting. The increase in plant height could mainly be due to availability of more appropriate temperature on mid September and early October planting; that reacted favo-

Table 1. Results of analysis of variance and F values of the investigated characteristics

Source of variance	Plant height (cm)	Stem diameter (cm)	Leaf length (cm)	Leaf width (cm)	Peduncle length (cm)	Flower head diameter (cm)	Bulb diameter (cm)	Bulb circum-ference (cm)	Bulb weight (cm)	Number of bulbils
Years	4.25	72.54**	0.61	53.65**	38.62**	4.24	5.26	1.52	53.87**	28.23**
Planting times	0.64	0.12	2.96	0.31	6.79*	0.38	16.11**	6.62*	5.88*	0.47
Interaction	0.33	0.85	1.77	0.34	0.26	0.32	8.38*	1.47	1.69	0.36

* Significant at 0.05 probability level; ** Significant at 0.01 probability level; ns – non-significant

Table 2. Mean values of plant height, plant stem diameter, leaf length and leaf width obtained from different planting times of *A. tuncelianum*

Planting times	Plant height (cm)			Stem diameter (cm)			Leaf length (cm)			Leaf width (cm)		
	2011–12	2012–13	Mean	2011–12	2012–13	Mean	2011–12	2012–13	Mean	2011–12	2012–13	Mean
1 Sept.	111.1	118.3	114.7	1.46	1.03	1.25	43.2	43.7	43.5	2.72	1.71	2.23
15 Sept.	112.7	123.9	118.4	1.43	1.03	1.23	43.4	41.8	42.6	2.80	1.85	2.33
1 Oct.	112.6	118.4	115.5	1.49	0.93	1.22	42.7	39.6	41.2	2.85	1.71	2.28
Mean	112.1	120.2		1.46 A	1.00 B		43.1	41.7		2.79 A	1.77 B	
LSD (0.05)		ns			Years: 0.26**			ns			Years: 0.73**	

** Means within a column and line followed by the same letter are not significantly different according to LSD test at $p \leq 0.05$
ns – non significant

urably with cloves to utilize their reserve foods to support their growth. Early September planting with hot temperature had negative impacts on growth and development of cloves that failed to provide proper growth environment to the Tunceli garlic cloves.

Plant stem diameter value was determined as 1.46 cm on the plants of first experimental year; whereas, their diameter reduced to 1.00 cm during 2nd year (tab. 2). No significant difference was noted in stem diameters based on planting dates during both years. It is known that plant diameter and length has direct relationship with lodging. Longer plants obtained from 2nd years planting did not gain stem diameter. It is well known that stem laying down or lodging occur if leverage force of the stem exceeds stem strength. Gaining of plant height was not desired for Tunceli garlic under semi-arid conditions, as the longer plants were prone to lodging at the time of harvest. The severity of lodging and the losses resulting from it depend on many environmental factors as well as on numerous plant characters [Zuber 1994]. The plant achieves greater lodging risk through increased growth and developing week leverage to support the plants. Mechanical lodging is triggered by strong wind and/or rain and can be intensified by an attack of insects or fungal pathogens [Pinthus 1973, Hoshikawa and Wang 1990, Crook and Ennos 1993]. Lodging is generally more common on heavy soils because of their relatively high water and nutrient holding capacity. The plants under rain produce huge amount of biomass which helps in "C" sequestration and accumulation of macro and micro nutrient elements in plant parts depending on the plant species [Dotaniya and Kushwah 2013]. Under such conditions lodging can be prevented by good drainage and cutting fertilizers to the plants to achieve the objective. The results are in agreement with Fischer and Stapper [1987], who found that lodging of wheat has adverse effect on yield and is ascribed to reduction in photo assimilate supply.

Tunceli garlic plant has opposed leaves on stem (tab. 2). Mean numbers of leaves per plant did not change significantly irrespective of planting dates or years. Similarly, no significant differences were noted in terms of leaf length based on planting times and years (tab. 2). Leaf length ranged 43.1 cm to 41.7 cm on plants obtained from first and second year respectively. Whereas, leaf width values were noted as 2.79 cm for the first year and 1.77 cm for the second year (tab. 2). Although, there was no significant difference of temperature between two years, more precipitation was received during 2nd year that affected these values negatively.

A. tuncelianum plant has a large attractive silver white, pink or purple very attractive inflorescence and is less pungent compared to other Allium species, that increases possibilities of using them as an ornamental plant in urban landscaping especially their use in rock and well drained rain gardens would be advisable. Like all Allium species, Tunceli garlic flower scape is inflated and fistulose that terminates with a multi – flowered head – like inflorescence. Bracteoles are present at the bases of the pedicels. The spathe is short and the flowers are campanulate or with spreading tepals [Fritsch and Friesen 1990]. Inflorescence diameter of Tunceli garlic was affected by different planting dates and years (tab. 3; figs 2 and 3) and bore a number of seeds. Inflorescence diameter in the field trial changed between 8.57 to 9.59 cm during first and 2nd year showing significant effects of temperature and precipitation during two years that ranged 8.94 cm to 9.16 cm (tab. 3).

Planting times and years significantly affected peduncle length ($p \leq 0.05$) (tab. 3). Peduncle length (leafless stem) varies according to population density. Peduncle length showed significant differences between years and planting times. Mean values of peduncle length was determined as 81.8 cm for first year and 92.2 cm for the second year. The maximum peduncle length values were recorded for the plants grown during the first year on mid September plantings, whereas, the minimum peduncle height was noted on plants obtained from early October planting (tab. 2); when the temperature had dropped significantly. The results support findings of Laskowska [1998], who reported positive effects of soil moisture due to bark mulching on induction of raceme length of *Scilla campanulata*.

Table 3. Mean values of stem length, flower diameter and bulb diameter obtained from different planting times of *A. tuncelianum*

Planting times	Peduncle length (cm)			Flower head diameter (cm)			Bulb diameter (cm)		
	2011–12	2012–13	Mean*	2011–12	2012–13	Mean	2011–12	2012–13	Mean
1 Sept.	84.2 a	93.3	88.8 a	9.63	8.72	9.16	3.73 bc	4.60 a	4.17
15 Sept.	84.5 a	94.7	89.6 a	9.57	8.68	9.12	3.65 bc	3.97 b	3.81
1 Oct.	76.5 b	88.6	82.6 b	9.58	8.30	8.94	3.54 c	3.43 c	3.49
Mean	81.8 B	92.2 A		9.59	8.57		3.64	4.00	
LSD (0.05)	Years: 7.21**; Planting time: 4.82*			ns			Int.: 0.39**		

* Means within a column followed by different small letters are significantly different according to LSD test at $p \leq 0.05$
** Means within a row followed by different capital letters are significantly different according to t test at $p \leq 0.01$
ns – non significant

Fig. 2. Tunceli garlic production at Ovacik district of Tunceli under local farmer's patronage

Fig. 3. Tunceli garlic production at the experimental station of Dicle University, Diyarbakır

Table 4. Mean values of bulb circumference, bulb weight and number of scale bulb obtained from different planting times of *A. tuncelianum*

Planting times	Bulb circumference (cm)			Bulb weight (g)			Number of bulbils		
	2011–12	2012–13	Mean	2011–12	2012–13	Mean	2011–12	2012–13	Mean
1 Sept.	15.6	16.7	16.1 a	35.5	57.4	46.4 a	2.67	1.73	2.20
15 Sept.	15.3	15.9	15.6 a	36.3	54.7	45.5 a	2.40	1.50	1.96
1 Oct.	14.7	14.2	14.4 b	31.0	40.8	35.9 b	2.76	1.47	2.12
Mean	15.2	15.6		34.3 b	50.9 a		2.61 a	1.57 b	
LSD (0.05)	Planting times: 1.1*			Years: 9.9** ; Planting times: 7.8*			Years: 0.93**		

Explanations as in Table 3

Whereas, significant years × planting times interaction was noted for bulb diameter ($p \leq 0.05$). It is assumed that larger the size of bulb or clove at the time of planting, has positive impacts on yield. The results of this study showed that the largest bulbs/cloves of 4.60 cm during 2nd year were obtained from the early September planting times; while the smallest bulbs/cloves of 3.43 cm were noted on early October planting time (tab. 3).

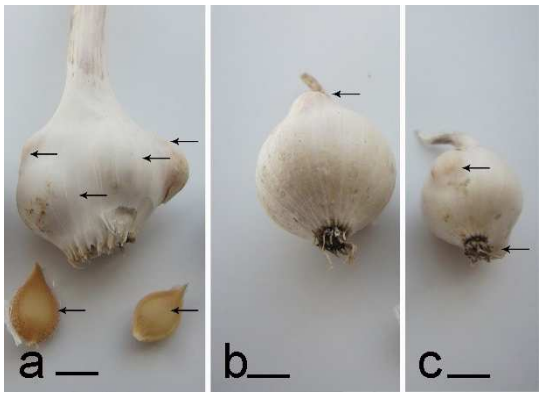

Fig. 4. Bulbils induction (a) during first year and (b, c) second year. Arrow heads points induced bulbils on main clove of Tunceli garlic during first and second year on the bulbs of Tunceli garlic at the Experimental Station of Dicle University, Diyarbakır

Bulb circumference values decreased progressively with each late planting times (tab. 4). The maximum circumference of 16.1 cm was noted from first and second planting; whereas, the minimum circumference of 14.4 cm was observed on third planting times (planting dates). The means of fresh bulb weight was recorded as 34.3 g for first year and 50.9 g for second year (tab. 4). In terms of planting times, early and mid September planting times were more favourable for weight gain compared to third early October planting time.

Mean number of bulbils obtained on mother bulbs were determined as 2.61 for the first year (fig. 4a) and 1.57 (fig. 4b, c) for the second year (tab. 4). It is reported that early planting was always essential to get higher number of bulbils and their yield was significantly reduced with delay in planting. It is clear that moisture stress induced more bulbils compared to 2nd year with abundant of soil moisture received in form of precipitation. The results are in compliance to the findings of Abraham-Juarez et al. [2010]. They found three individual *Agave tequilana* plants under drought (water) stress produced bulbils more quickly.

It was noted that for Tunceli garlic increase in bulb size positive impact on bulb diameter, bulb circumference and bulb weight as well are in line with Addai and Scott [2011], who reported that bulb size at planting influenced vegetative growth in hyacinth and the lily and when the size of the planted bulb increased, other parameters related to bulb showed positive increase in proportion to the size of the planted bulbs. Moreover, they suggested that the larger bulbs at the time of planting grew faster to

complete their life cycle compared to medium and small sized bulbs; where senescence occurred earlier.

Tunceli garlic grows on mountainous rocky slopes at its natural habitat on acidic soils that have good drainage (fig. 1) under hot temperate conditions that help the cloves to release dormancy [Finch-Savage and Leubner-Metzger 2006]. It is well known that Allium species prefer light or medium consistency soils pH 4.5–7.5, that can hold a moderate quantity of water and organic matter [Rahman et al. 2002, Ibrahim 2010]. They do not need high fertilization compared to other species, as their cloves accumulate sufficient amount of nutrients that suffice their needs during growth [Fascetti et al. 2014]. It is well known that Tunceli garlic has very long dormancy period. The cloves do not sprout until the beginning of spring (March); when temperature begins to increase. Semi-arid climate and alkaline alluvial soil conditions at Dicle University Diyarbakir experimental area were favourable for growth and development of the plant and did not hamper their growth at new place.

During survey of the natural habitat of plant, it was noted that the plant is harvested close to mid of July at its habitat with hot temperate climate. Whereas the results of this study showed that; regardless of the planting times; it was possible to mature and harvest the plants during mid May of first year and June of 2nd year, when cultivated under semi-arid climatic conditions on alkaline clay soils. Tunceli garlic matured earlier during first year with less rains and delayed maturing during 2nd year with more precipitation. These results underscore delaying effects on maturing of Tunceli garlic under moist conditions. Comparing, maturing at habitat and under semi-arid conditions, the Tunceli garlic matures toward mid of August at its habitat. Even this delay in maturing was early compared to the natural habitat of Tunceli garlic. The results of this study show that the maturity period of the plant could be significantly reduced if the cloves are planted under semi-arid conditions. This reduction in maturity time signifies that the plant could be efficiently conserved outside its natural habitat without any problem.

The results are in agreement with Rahman et al. [2002]; who noted that December (early) transplant for onion had the tallest plants and bulb yield compared to January transplants. They observed that plant height exhibited strong positive correlation with number of leaves per plant, bulb diameter and bulb yield per plant. Whereas, Ibrahim [2010] observed that onions grown at monthly intervals from February to June were affected by changes in mean temperature fluctuations during successive sowings.

CONCLUSION

It is concluded that endemic threatened Tunceli garlic could also be conserved outside its natural habitat. The results of the study also underscore successful cultivation of Tunceli garlic under semi-arid conditions on alkaline alluvial soils profitably with early harvest (mid May–June) compared to its harvest at its habitat (mid of July); with hot temperate climate. Furthermore, its cultivation elsewhere (outside its natural habitat) will decrease pressure on its population at its natural habitat and may help in earning of the plant economically. The results also suggest possible use of the plant in landscaping or rain and rock gardens using early or mid September plantings.

ACKNOWLEDGEMENTS

This work was supported by a grant (Project number: 110 O 703) from the Scientific and Technical Research Council of Turkey (TUBITAK).

REFERENCES

Abraham-Juarez, M.J., Martinez-Hernandez, A., Leyva-Gonzalez, M.A., Herrera-Estrella, L., Simpson, J. (2010). Class I KNOX genes are associated with organogenesis during bulbil formation in *Agave tequilana*. J. Exp. Bot., 61(14), 4055–4067.

Addai, I.K., Scott, P. (2011). Influence of bulb sizes at planting on growth and development of the common hyacinth and the lily. Agric. Biol. J. North Am., 2(2), 298–314.

Block, E. (2010). Allium botany and cultivation, ancient and modern. In: Garlic and other alliums: the lore and the science, Block, E., Royal Society of Chemistry, Cambridge, 4–6.

Crook, M.J., Ennos, A.R. (1993). The mechanics of root lodging in winter wheat, *Triticum aestivum* L. J. Exp. Bot., 44, 1219–1224.

Dotaniya, M.L., Kushwah, S.K. (2013). Nutrients uptake ability of various rainy season crops grown in a vertisol of central India. Afric. J. Agric. Res., 8(44), 5592–5598.

Etoh, T., Simon, P.W. (2002). Diversity, fertility and seed production of garlic. In: Allium Crop Science: Recent Advances, Rabinowitch, H.D., Currah, L. (eds). CABI Publishing, New York, pp. 101–117.

Fascetti, S., Potenza, G., Castronuovo, D., Candido, V. (2014). Wild geophytes of ornamental interest in the native flora of southern Italy. Ital. J. Agron., 9(595), 99–106.

Finch-Savage, W.E., Leubner-Metzger, G. (2006). Seed dormancy and the control of germination. New Phytol., 171, 501–523.

Fischer, R.A., Stapper, M. (1987). Lodging effects on high-yielding crops of irrigated semidwarf wheat. Field Crops Res., 17(3–4), 245–258.

Friesen, N., Fritsch, R.M., Blattner, F.R. (2006). Phylogeny and new intrageneric classification of *Allium* L. (Alliaceae) based on nuclear ribosomal DNA ITS sequences. Aliso, 22, 372–395.

Fritsch, R.M., Friesen, N. (1990). Evolution, Domestication and Taxonomy. In: Allium crop science: recent advances, Rabinowitch, D., Currah, L. (eds). CAB International, Wallingford, 5–30.

Hoshikawa, K., Wang, S.B. (1990). Studies on lodging in rice plants. Jpn. J. Crop Sci. 59, 809–814.

Ibrahim, N.D. (2010). Growth and yield of Onion (*Allium cepa* L.) in Sokoto. Agric. Biol. J. North Am., 1(4), 556–564.

Ipek, M., Ipek, A., Simon, P.W. (2008). Genetic characterization of *Allium tuncelianum*: an endemic edible Allium species with garlic odor. Sci. Hortic. 115, 409–415.

Kamenetsky, R., Rabinowitch H.D. (2006). The genus *Allium*: A developmental and horticultural analysis. Horticultural Reviews, 32, 329–378.

Kizil, S., Tekin, F., Khawar, K.M., Saglam, S., Ertekin, A.S., Arslan, N. (2012). An investigation about economically important bulbous plants found in Southeastern and East Anatolia Regions of Turkey. XI. International Flower Bulbs and Herbaceous Perennials (ISHS), Antalya, Turkey.

Kizil, S., Içgil, D.Y., Khawar, K.M. (2014). Improved *in vitro* regeneration and propagation of Tunceli garlic (*Allium tuncelianum* L.) from sectioned garlic cloves, leaves and root explants. J. Hortic. Sci. Biotech., 89(4), 408–414.

Laskowska, H.K. (1998). Morphological characteristics associated with lodging of tobacco. Crop Sci., 33, 58–62.

Pinthus, M.J. (1973). Lodging in wheat, barley and oats: the phenomenon, its causes and preventative measures. Adv. Agron., 25, 209–263.

Rahman, M.A., Saha, S.R., Salam, M.A., Masum A.S.M.H., Chowdhury, S.S. (2002). Correlation and path coefficient analysis in onion (*Allium cepa* L.). J. Biol. Sci., 2(8), 533–534.

Stavelikova, H. (2008). Morphological characteristics of garlic (*Allium sativum* L.) genetic resources collection – Information. Hort. Sci. (Prague), 35(3), 130–135.

Zuber, U.R.S. (1994). Molecular and morphological aspects of lodging resistance in spring wheat (*Triticum aestivum* L.). PhD thesis. Swiss Federal Institute of Technology, Zurich, 77 p., http://e-collection.library.ethz.ch/eserv/eth:39664/eth-39664-02.pdf [accessed: May 15, 2016].