Kiwano (Cucumis metuliferus E. Meyer Ex. Naudin) response to weed management practice and planting time in Eastern Slavonia

ŠTEFANIĆ, Edita; LUKAČEVIĆ, Marin; RAŠIĆ, Sanda; LUCIĆ, Pavo

Preliminary communication
DOI: /10.5513/JCEA01/23.3.3562
Journal of Central European Agriculture, 2022, 23(3), p.624-631

Kiwano (*Cucumis metuliferus* E. Meyer Ex. Naudin) response to weed management practice and planting time in Eastern Slavonia

Značaj suzbijanja korova i roka sjetve u proizvodnji kivana (*Cucumis metuliferus* E. Meyer Ex. Naudin) na području istočne Slavonije

Edita ŠTEFANIĆ[1] (✉), Marin LUKAČEVIĆ[2], Sanda RAŠIĆ[1], Pavo LUCIĆ[1]

[1] Josip Juraj Strossmayer University in Osijek, Faculty of Agrobiotechnical Sciences, Vladimir Prelog 1, 31 000 Osijek, Croatia

[2] Student of Faculty of Agrobiotechnical Sciences, V. Prelog 1, 31 000 Osijek, Croatia

✉ Corresponding author: estefanic@fazos.hr

Received: March 15, 2022; accepted: June 28, 2022

ABSTRACT

Seed germination, growth, flowering and yields of kiwano (*Cucumis metuliferus* E. Meyer Ex. Naudin) were examined in eastern Slavonia during 2021 growing season. The objective of this study was to determine agro-morphological diversity within kiwano growing under different weed management practices and sowing time. The experiment was arranged as a 3 x 3 factorial design with three replications. Factors included three weed management options (wheat straw mulch, cultivation and un-weeded control) and three planting dates (early, mid and late May). A typical summer weed community that develops during experiment dominated with bristly foxtail (*Setaria verticilata* (L.) P. Beauv.) and redroot pigweed (*Amaranthus retroflexus* L.) while the others were with lower relative density and frequency per unit area and with the lower impact on the crop. Weed control was very effective compared to weedy check. However, sowing date appears as a critical factor in kiwano production, influencing not only emergence, growth and flowering, but also fruit number and size. This study concluded that mid sowing time and cultivation as a weed control measure has a highest agronomic potential for a kiwano production following by mid and early sowing time with mulch as a weed control measure.

Keywords: kiwano, weed community, mulch, cultivation, sowing time

SAŽETAK

U pokusu provedenom u istočnoj Slavoniji tijekom 2021. godine analizirano je nicanje, rast, cvatnja i prinos kivana (*Cucumis metuliferus* E. Meyer Ex. Naudin). Cilj istraživanja bio je utvrditi agromorfološke razlike pri proizvodnji kivana uzgajanog s različitim sustavima kontrole korova te različitim rokovima sjetve. Pokus je postavljem kao 3 x 3 faktorski plan s tri ponavljanja. Faktori su uključivali tri varijante suzbijanja korova (primjena slame kao malča, kultivacija i kontrolna zakorovljena varijanta) te tri roka sjetve (rani, srednji i kasni). Tijekom pokusa se razvila tipična zajednica ljetnih korova u kojoj su dominirali pršljenasti muhar (*Setaria verticilata* (L.) P. Beauv.) i oštrodlakavi šćir (*Amaranthus retroflexus* L.), dok su ostali korovi bili niske relativne gustoće i frekvencije po jedinici površine i slabog utjecaja na uzgajane biljke. Tretmani suzbijanja korova bili su vrlo učinkoviti u usporedbi sa zakorovljenom kontrolom. Međutim, vrijeme sjetve pokazalo se kao kritičan faktor u proizvodnji kivana, i imalo je utjecaja ne samo na nicanje, rast i cvatnju, već i na broj i veličinu plodova. Zaključno, srednji rok sjetve i kultivacija kao mjera suzbijanja korova pokazali su najveći agronomski potencijal za proizvodnju kivana, a slijede srednji i rani rok sjetve uz primjenu malča za suzbijanje korova.

Ključne riječi: kivano, korovna zajednica, malč, kultivacija, vrijeme sjetve

INTRODUCTION

Kiwano (*Cucumis metuliferus* E. Meyer Ex. Naudin) or sometimes called African horned melon, is a herbaceous annual climbing plant, member of *Cucurbitaceae* family (Bisognin, 2002). The main vine is highly branched with the 3-palmately shallow lobed blade leaves. Plant is monoecious with male (staminate) flowers typically appearing several days before female (pistillate) flowers. Kiwano flowers forms a clusters of 1 to 4, and are small sized, bright yellow, funnel-shaped, axillary and opening to 5 lobes. The fruit (berries) is ellipsoidal in shape, about 10 cm long, covered with many blunt thorns on its surface. While immature it is light green, in ripening it is bright orange (Bester and Condy, 2013).

The taste of the fruits is between the bananas and lemon and can be stored for some months at room temperature in dry places, without rotting (Ferrara, 2018). Inside, the mesocarp is a juicy green slimy mass with numerous (hundreds per fruit) smooth white seeds, rich in various phytochemical components important in the daily diet (Romero-Rodriguez et al., 1992, Usman et al., 2015). The fruit has high economic and nutritional value but still has not been fully exploited (Morton, 1987, Šeregelj et al., 2022).

Kiwano is endemic to the semi-arid regions of southern and central Africa. It dominates both tropical and subtropical areas at an altitude range of 210 to 1 800 m above sea level, on shallow or deep, well-drained, mostly alluvial sandy soil on river banks or flood plains (Bester and Condy, 2013). Also, it can be found on clay soil and rocky slopes and on variety of habitats. Nowadays, it is growing as an ornamental fruit in the United States, New Zealand, Kenya, and Israel but its market is expanding (Benzoni et al., 1991).

Like other plants from *Curcubitaceae* family, kiwano shows rapid growth, fears to cold and good supply of water, and can be growing practically anywhere provided the season is warm (Marsh, 1993). However, the crop remains less popular among the farmers and consumers in most parts of the world despite the numerous agronomic, nutritional, medicinal and economic advantages (Aliero and Gumi, 2012). This is the reason why its agronomic, nutritional and economic potential is not well documented.

Kiwano has been successfully grown in Croatia more than a decade, particularly in Bjelovar-bilogora and Sisak-moslavina counties (Šatović, 2012). As with the newest crops, unanticipated production problems have been the most challenging. Therefore, this study targeted agronomic performance (weed management and planting date) and morphological trait of kiwano growing in the conditions of eastern Slavonia.

MATERIALS AND METHODS

The study was conducted during 2021 in Posavski Podgajci (44°55'N 18°49'E), a village near city of Županja in Vukovar-Syrmia County (eastern part of Slavonia region in Croatia). This area is characterized by a temperate continental climate with a long-term annual average temperatures of 11 °C, and long-term total annual precipitation of 700 mm. Climatic conditions during kiwano growing season is shown on Figure 1. The site has been usually used for vegetable production and was previously year sown with kidney bean (*Phaseolus vulgaris* L.).

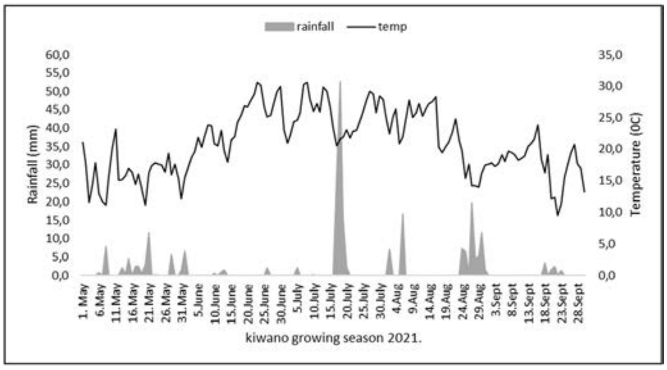

Figure 1. Climatic conditions for Županja during the kiwano growing season

Source: Croatian Meteorological and Hydrological Service (https://meteo.hr/index_en.php)

The trial was arranged as 3 x 3 factorial treatment with three replications. The main plots were 3 m wide and 10 m long, and kiwano was planted manually at a spacing of 1 m by 1 m. Agrotechnical measures were similar to the local practice for cucumber (*Cucumis sativus* L.) production growing on a net (Matotan, 2004). Factors included three weed management options (wheat straw mulch, cultivation and control plots where weeds were left to develop) and three planting dates (early: May 12th; mid: May 19th; and late: May 26th). Wheat straw was spread uniformly over and between the rows at crop emergence in layers about 8-10 cm, for each planting date respectively, while cultivations were performed five times throughout the season when weeds start to re-infested the plots using hand power rototiller. Soil were cultivated between the crop rows during following kiwano growth stages (according to BBCH Monograph, 2018):

i) When cotyledons completely unfolded eq. 10 BBCH scale (3-4 weeks after planting)
ii) during first leaves development, eq. 11- 14 BBCH scale (5-6 weeks after planting)
iii) flowering eq.62-64 BBCH scale (7-8 weeks after planting)
iv) development of fruit; eq. 73-74 BBCH scale (10-13 weeks after planting)
v) fruit ripening; eq. 85 BBCH scale (16-18 weeks after planting).

Five randomly selected kiwano plants from each plot were measured through the growing season to determine following agronomic traits: days to emergence, days to first leaves, days to male and female flowering, days to first fruits and days to maturity. Kiwano yield was determined by harvesting (September 29th) all fruits that were picked from the same selected plants. Fruits were counted, weighted, and expressed as a number per plants and g per plant, respectively. Additionally, all fruits were graded as large (≥ 150 g) or small (< 150 g).

Weed community was analyzed at the time of its peak development (first decade of July). This correspond to growth stage 6: Flowering (main shoot) according to BBCH Monograph (2018). Plants were sampled from five (0,5 x 0,5 m) quadrats per each control plots, and all weeds within each quadrat were counted by species. Plants nomenclature was unified in accordance with Nikolić (2019). In the scatter plot (rel. frequency vs rel. density, Figure 1) of the top ranked species five groups were detected: I – very abundant, II – abundant, III – locally abundant, IV – moderate abundant and V – common, according to a method used by Thomas and Ivany (1990).

Data were analyzed using repeated measure ANOVA in SPSS program (IBM® SPSS Statistics for Windows, version 22) with planting time as repeated measure. Mauchly's criterion test for the compound symmetry of the variance-covariance matrix was obtained automatically, together with corrected significance levels in case of the rejection of the symmetry assumption (Pallant, 2020). Bonferroni post-hoc test was used for the mean comparison procedures where the interaction between the time (planting time) and main effect (weed management) exists.

RESULTS AND DISCUSSION

Weed community that was found in control weedy plots consist of the summer weed species with various abundance. Community was dominated with two species: bristly foxtail (*Setaria verticilata* (L.) P. Beauv.) and redroot pigweed (*Amaranthus retroflexus* L.), while the other weeds were with lower relative density and frequency per unit area and with lower impact on the crop (Figure 2).

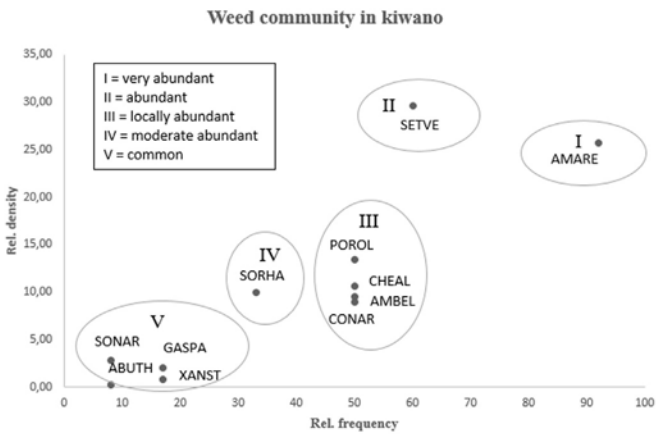

Figure 2. Abundancy of weeds in kiwano during the study period

Bayer code of Latin names of weeds: I: SETVE (*S. verticillata*), AMARE (*A. retroflexus*), II: SORHA (*Sorghum halepense* (L.) Pers.), POROL (*Portulaca oleracea* L.), CONAR (*Convolvulus arvensis* L.), AMBEL (*Ambrosia artemsiifolia* L.), CHEAL (*Chenopodium album* L.), III: ABUTH (*Abutilon theophrasti* Medik.), SONAR (*Sonchus arvensis* L.), XANST (*Xanthium strumarium* L.), GASPA (*Galinsoga parviflora* Cav.)

Weed infestation on control plots significantly affected all evaluated kiwano agronomic traits. In competition with weeds, kiwano developed significantly slower (*P*<0,05) than on plots where weeds were controlled throughout the growing season (Figure 3). Moreover, at first sowing date in early May all measured kiwano plants failed to survive competition from weeds soon after they formed first leaves. For the second sowing dates the same pattern was also observed. Without weed control kiwano plants took the longest period to emerge, develop first leaves, male and female flowers, first fruit and to mature, while the third sowing date showed variations among observed agronomic traits.

The between-subjects repeated measures ANOVA indicated that there were significant weed treatment (WT) x sowing time (ST) interactions for following morphometric variables: days to male flowering, days to female flowering, days to first fruit and days to maturity (Table 1).

Closer inspection of these results showed a contrasting pattern among the studied treatments (Figure 3). In early planting date a delay was observed on cultivated plots for the starting of male and female flowering (8 days and 10 days, respectively) compared to plots with mulch, while days to first fruit development and maturity did not differ significantly between those two weed control treatments.

Rapid plant growth in mid planting date was observed on plots with cultivation where kiwano took 45 and 47 days to start with male and female flowering, respectively. Plots with straw mulch on the same planting date had significantly (*P*<0,05) delay to starting male (12 days) and female (13 days) flowering. Fruit development and maturity also started significantly later on plots with mulch (Figure 3).

The plants sown at the end of May (late planting date) failed to grow well and showed significant variability in morphometric characteristics soon after the development of first leaves on main vine, confirming the findings of Owino et al. (2020) regarding possible genetic variation for heat tolerance for kiwano.

The between-subjects repeated measures ANOVA (Table 2) indicated that there were significant weed treatment (WT) x sowing time (ST) interactions for mean number of fruit per plant and mean yield (g/plant).

Kiwano yield and number of fruit per plant is significantly affected by the intensity of weed infestation. The yield decreases due to presence of weeds by 71% and 74% in comparison with the permanently weeded treatments (mulch and cultivation throughout the vegetation, respectively). There were no significant differences in yield and yield components among the weed management treatments (Figure 4).

Table 1. Repeated-measures ANOVA for the effect of agricultural management system on morphometric characteristics of kiwano

Variable	df	Morphometric characteristics					
		Days to emergence	Days to first leaves	Days to male flowering	Days to female flowering	Days to first fruits	Days to maturity
Between-subject source							
Weed Treatment (WT)	2	69,80***	325,91***	2301,48**	4848,84*	7300,84*	5908,86*
Error	12	2,08	90,66	461,40	533,62	791,45	1484,87
Within-subject source							
Sowing time (ST)	2	439,39***	1078,57***	10,66***	10415,24***	14080,84**	16460,17**
ST x WT	4	5,53NS	9,68 NS	7,39***	15095,95***	18540,08**	15499,08**
Error	24	10,09	231,73	425,98	11360,13	16967,73	2006,15

Notes: The degrees of freedom, Type III sums of squares, and significance levels (**P*<0.05; ***P*<0.01; ****P*<0.001.) of effects are shown for each variable. Within-subject analysis used Geisser-Greenhouse adjusted probabilities. System means and standard errors are shown in Figure 2.

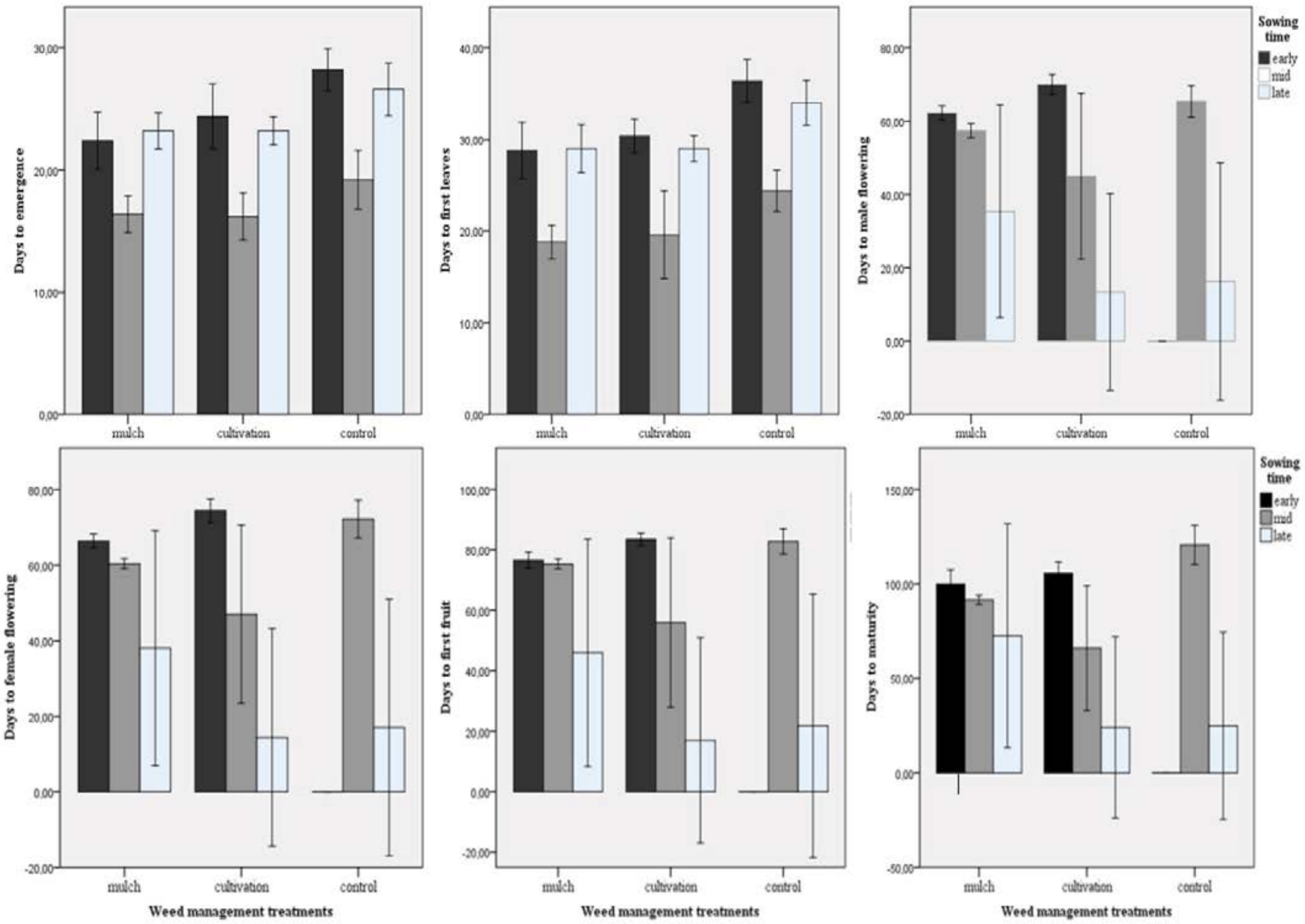

Figure 3. Effect of weed management and sowing time on morphometric characteristics of kiwano. Values are means ±SE of 5 randomly selected kiwano plants

Table 2. Repeated-measures ANOVA for the effect of agricultural management system on kiwano yield

Variable	df	Kiwano yield		
		Number of fruit / plant	Yield g/plant	Fruit number (≥ 150 g)
Between-subject source				
Weed Treatment (WT)	2	59,24*	920976,04*	6,178
Error	12	111,33	2425994,26	27,067
Within-subject source				
Sowing time (ST)	2	128,17***	1626903,64***	6,178**
ST x WT	4	32,48 *	504289,15 **	3,289
Error	24	114,66	1484046,53	16,533

Notes: The degrees of freedom, Type III sums of squares, and significance levels (**P*<0.05; ***P*<0.01; ****P*<0.001) of effects are shown for each variable Within-subject analysis used Geisser-Greenhouse adjusted probabilities. System means and standard errors are shown in Figure 3.

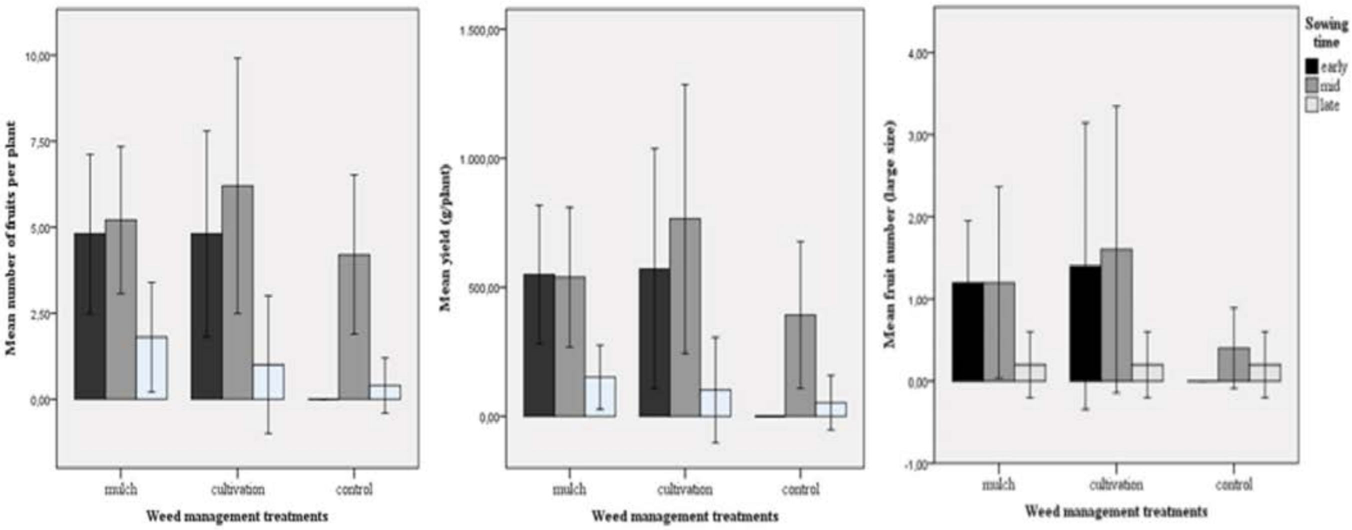

Figure 4. Effect of weed management and sowing time on yield and yield components of kiwano. Values are means ±SE of 5 randomly selected kiwano plants

However, sowing time represents a critical factor, and associated with environmental conditions, influence not only emergence, growth and flowering (Figure 3), but fruit number and size (Figure 4).

The study findings indicated that mid sowing time and cultivation as a weed control measure has a highest agronomic potential for kiwano production following by mid and early sowing time with mulch as a weed control measure. Researches on conditions for germination and effect of sowing dates on kiwano development in Israel showed that optimal germination was between 20 and 30 °C, while lower or higher temperature will delay or even inhibit plant germination (Benzioni et al., 1991).

When temperatures is optimal, kiwano will complete germination in three to eight days. However, at lower temperature (there were 15 °C at early, 13,6 °C at mid and 16,3 °C at late sowing date; Figure 1) germination were commenced at about 3 weeks. Differences in all observed morphometric characteristics were significant (Table 1, Figure 3) and kiwano at mid sowing time reached each observed stage earlier than plants from early or late sowing time.

Only 25% of fruits were classified as large, and would not command premium prices in the market (Joy, 1987). Late sowing time is not recommended since kiwano produced comparatively lower yield on both weed management treatments as well as number of fruit per plant and number of fruits larger than 150 g (Table 3).

It appears that kiwano as a new crop could successfully be grown in eastern Slavonia using cultural practices as it is for cucumber (*Cucumis sativus* L.). However, further research is needed regarding agrotechniques and fruit quality to make this crop attractive for growers and commercialization.

Table 3. Kiwano fruit size, yield and fruit number at several sowing dates and weed management treatments

Treatment	Sowing date	Mean yield (g/plant) + STD*		Total fruit number (per 5 plant)	
		small fruits < 150 g; large fruits > 150 g			
		< 150 g	> 150 g	< 150g	> 150 g
Mulch	Early	83 (28,79)	209 (27,67)	18	6
	Mid	86 (37,25)	164 (15,78)	20	6
	Late	63 (27,25)	115	8	1
Cultivation	Early	70 (24,83)	205 (78,59)	17	7
	Mid	96 (30,71)	202 (28,76)	23	8
	Late	82 (41,24)	181	4	1
Control	Early	0	0	0	0
	Mid	83 (28,76)	191 (28,28)	8	2
	Late	72	192	1	1

*STD= standard deviation

CONCLUSION

Kiwano could be successfully grown in eastern part of Slavonia region using cultural practices similar to cucumber production. If not controlled, a typical row-crops weed community tend to develop and seriously compete with the crop. Proper weed control, i.e. cultivation several time (when needed) during the growing season appears to be the best management option. Sowing date is a critical factor, particularly as associated with environmental condition. Mid sowing time and cultivation as a weed control measure showed the highest agronomic potential for kiwano production in this region following by mid and early sowing time with mulch as a weed control measure. However, the differences observed among investigated management systems in this experiment indicate challenges that exist for the development of ecologically based kiwano production in northeastern Croatia.

REFERENCES

Aliero, A.A., Gumi, A.M. (2012) Studies on the germination, chemical composition and antimicrobial properties of *Cucumis metuliferus*. Annals of Biological Research, 3 (8), 4059-4064. Available at: http://scholarsresearchlibrary.com/archive.html [Accessed 25 February 2022].

Benzioni, A., Mendlinger, S., Ventura, M. (1991) Effect of Sowing Dates, Temperatures on Germination, Flowering, and Yield of *Cucumis metulferus*. HortScience, 26 (8), 1051-1053. DOI: https://doi.org/10.21273/HOPRTSCI.26.8.1051

Benzioni, A., Mendlinger, S., Ventura, M., Huyskens, S. (1993) Germination, Fruit Development, Yield, and Postharvest Characteristics of *Cucumis metuliferus*. In: Janick, J., Simon, J.E., eds. New Crops. New York: Wiley, 553-557.

Bester, S.P., Condy, G. (2013) *Cucumis metuliferus* E. Mey. Ex Naudin. Flowering Plants of Africa., 63, 56-64. Available at: https://www.researchgate.net [Accessed 25 February 2022].

Bisognin, D.A. (2002) Origin and evolution of cultivated cucurbits. Ciencia Rural, 32 (5), 715-723. DOI: https://doi.org/10.1590/S0103-84782002000400028

Ferrara, L. (2018) A fruit to discover: *Cucumis metuliferus* E. Mey Ex Naudin (Kiwano). Clinical Nutrition Metabolism, 5, 1-2. DOI: https://doi.org/10.15761/CNM.1000109

IBM Corp. (2017) IBM SPSS Statistics for Windows. Armonk, NY: IBM Corp.

Joy, C. (1987) Selected European markets for tropical fruit and vegetables. Tropical Development and Research Institute Report, London G 201, p 95.

Marsh, D.B. (1993) Evaluation of *Cucumis metuliferus* as a specialty crop for Missouri. In: Janick, J., Simon, J.E., eds. New crops, New York: Wiley, 558-559.

Matotan, Z. (2004) Suvremena proizvodnja povrća. Zagreb: Nakladni zavod Globus.

Medlinger, S., Benzioni, A., Huyskens, S., Ventura, M. (1992) Fruit development and postharvest physiology of *Cucumis metuliferus* Mey., a new crop plant. Journal of Horticultural Sciences, 67 (4), 489-493. DOI: https://doi.org/10.1080-00221589.1992.11516274

Meier, U. (2018) BBCH Monograph. Growth stages of mono- and dicotyledonous plants. Quedlinburg, Julius Kühn-Institut. DOI: https://doi.org/10.5073/20180906-074619

Morton, J.F. (1987) The horned cucumber alias “Kiwano” (*Cucumis metuliferus*, *Cucurbitaceae*). Economic Botany, 41, 325-326.

Nikolić, T. (2019) Flora Croatica Database, Prirodoslovno-matematički fakultet, Sveučilište u Zagrebu [Online] Available at: http://hirc.botanic.hr/fcd. [Accessed 16 July 2020].

Owino, M.H., Gichimu, B.M., Muturi, P.W. (2020) Agro-morphological characterization of horned melon (*Cucumis metuliferus*) accessions from selected agro-ecological zones in Kenya. Australian Journal of Crop Science, 14 (09), 1487-1496. DOI: https://doi.org/10.21475/ajcs.20.14.09.p2642

Pallant, J. (2020) SPSS Survival Manual. 7th Ed., London, UK: McGraw-Hill Education.

Romero-Rodriguez, M.A., Vasquez-Oderiz, M.L., Lopez-Hernandez, J., Simal-Lozano, J. (1992) Physical and analytical characteristics of the kiwano. Journal of Food Composition and Analysis, 5, 319-322. DOI: https://doi.org/10.1016/0889-1575(92)90065-R

Šatović, R. (2012) Mogućnosti uzgoja kiwana u Zagrebačkoj županiji. Master thesis. Osijek: J. J. Strossmayer University of Osijek.

Šeregelj, V., Šovljanski, O., Tumbas Šaponjac, V., Vulić, J., Ćetković, G., Markov, S., Čanadanović-Brunet, J. (2022) Horned Melon (*Cucumis metuliferus* E. Meyer Ex. Naudin) – Current Knowledge on Its Phytochemicals, Biological Benefits, and Potential Applications. Processes, 10, 94. DOI: https://doi.org/10.3390/pr10010094

Thomas, A. G., Ivany, J. A. (1990) The weed flora of Prince Edward Island cereal fields. Weed Science, 38, 119-124. DOI: https://doi.org/10.1017/S0043174500056241

Usman, J.G., Sodipo, O.A., Kwaghe, A.V., Sandabe, U.K. (2015) Uses of *Cucumis metuliferus*: A Review. Cancer Biology, 5, 24-34. Available at: http://www.cancerbio.net [Accessed 25 February 2022].