Effects of Cultivation Method on Seed Yield and Quality of Bitter Gourd

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Abstract This experiment was carried out to study the possibility of producing germinating seeds of bitter gourd (*Momordica charamtia* L.) in the climatic conditions of Europe. Seeds of Indian cultivar 'Nana' were sown in the greenhouse and produced transplants were planted on the field. The plants were cultivated in the field in 2 ways: tied to the sticks or creeping on the ground. During the vegetation, the ripen fruits with seeds were collected 6 times, and after extracting, they were germinated in the laboratory following the routine ISTA rules. The best transplants of bitter gourd were received within one month from the seeds emerging 51.8%. The transplant of bitter gourd had average height of 7 cm, 3 - 4 leaves, out of which the biggest had the width of 5 cm. Such transplants would grow into fruiting plants. When growing bitter gourd for seeds, the earliest fruits were harvested from the plants tied to the sticks. Moreover, the best seeds were harvested from 2/3 of early fruits. For the purpose of seed production, it is recommended to keep only 3 - 4 fruits per plant and remove other fruits. The produced seeds germinated from 8% to 24%. If the plants were tied to the sticks, their fruits ripened earlier. The used production way and time of harvest of fruits had no effect on the seed germination. The cultivation methods of bitter gourd plants had no effect on the chemical components of fruits.

Key words Bitter gourd, Seeds, Europe, Cultivation method

1 Introduction

Bitter gourd (*Momordica charantia* L.) is a cucurbit vegetable species well-known in the Far East (China, Japan and Korea) for thousands of years. It is a warm-season crop with fruit containing low content of sugar, so it is a highly recommended food for diabatic people[1].

In the traditional Chinese medicine, the species has been used not only against malfunctions in sugar production and metabolism, but also to cure diseases, *e. g.* some kinds of cancer[2]. The bitter gourd's seeds are hidden in the fleshy fruit. The ripen seeds are wrapped in a red tissue[3]. It is also used as carminative, emmenagogue, in the treatment of colics, and as antiviral, anthelmintic, anti-malarial, anti-microbial remedy[4]. These components of bitter melon with auxiliary hypoglycemic, lipid-lowering, anti-oxidation, enhance immunity and prevention of obesity and other health functions study provide a favorable base for further works[5]. In Poland, the production and use of bitter gourd is practically unknown. It is only known amongst few amateur gardeners and vegetable breeders[6].

This experiment is mainly intended to determine the best way to produce bitter gourd transplants, find out the best way of growing bitter gourd, and check when producing in the field conditions of Europe, one can produce germinating seeds.

2 Literature review

Bitter gourd (*Momordica charantia* L.), also called bitter melon or balsam pear, belongs to the cucurbit botanical family (*Cucurbitaceae*). It is an annual, herbaceous, climber growing in tropical areas of Asia, Amazon, East Africa, and the Caribbean. The specious comes from tropical regions of southern Asia, China or India[7]. The newest ethno-botanical investigations have revealed that bitter gourd cultivars were derived from the local wild types and local variant populations, through plant utilization and habitat modifications, accelerated greater diversity among cultivated strains than amongst the local wild types[8]. It is cultivated and used as a vegetable and medicine throughout the world[9].

Vines of bitter gourd grow very quickly (5 - 7 cm overnight), and have a very strong branching ability. Smaller stems could also get side branches. So, in commercial cultivation, one must not only keep timely pruning and remove side branches out, but also keep light for blooming flowers and enlarging fruits[10].

China has 500 years of the bitter gourd cultivation history. It is one of the main vegetable species in South China. In recent years, bitter gourd cultivation in the open field and protected area of northern areas is increasing year by year[11]. In China, bitter gourd is produced mainly in the Southern China, such as Guangdong, Hainan and Fujian.

Bitter gourd can be used as a vegetable as well as medicine throughout the world[12]. It has been widely used in medical treatment of diabetes mellitus from a long time. The enzyme of bitter gourd shows desirable properties for various applications[34].

In the climatic conditions of Europe, using a proper cultivation method, it is possible to produce germinating seeds of bitter gourd.

3 Materials and methods

3.1 Characteristic of the breeding materials The seeds of bitter gourd (*Momordica charamtia* L.) used in the experiment were the Indian cultivars 'Nana', which came from the 2011 year

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of production and were imported to Europe.

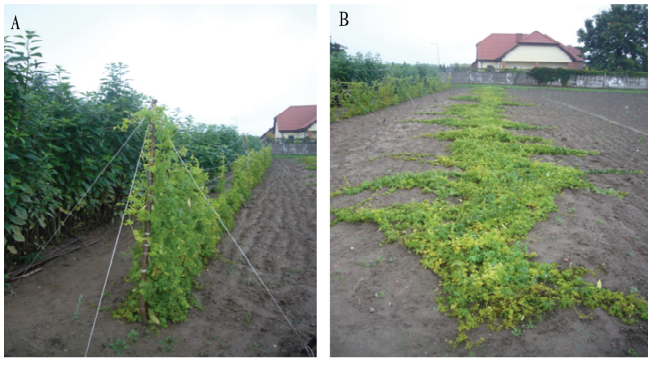
3.2 Field experiment

3.2.1 Field and soil. One year before starting the experiment, the field was left idle. Just before planting the transplants, the rotation machine was used to remove weeds. The used soil was podsolic.

3.2.2 Experiment process. The seeds were sown into trays with peat. Then, the trays with seeds were placed into unheated plastic tunnels. Next, they were watered once a day. Altogether, 4 trays of 100 seeds were prepared.

They were planted into 2 rows, 90 plants for each row. One of them was supported with wooden sticks and kept straight by the string tied to the plants. The plants were planted at 1 m spacing in a row. The rows were 4 m apart from each other. The spare plants had also supported sticks and were tied with the string.

The plants with the string on the sticks were successively tied up to the string as they were growing (Fig. 1). The plants with no stick were creeping on the field.



Note: A. tied to the sticks, B. creeping on the ground.

Fig. 1 Bitter gourd plants grown on the field in two different ways

3.2.3 Sample collection. Fruits were selected for chemical analyses. During fruit bearing period, 3 fruits from each row were selected.

Collecting seeds from the field. Six times the mature fruits with the ripen seeds were collected. Then, the fruits were taken to the room to ripen for 1 – 2 weeks. Next, the seeds were extracted from the fruits, rinsed with water and dried on the paper.

Field morphological observations of the plants. In normal conditions, 20 best plants on each row were selected and analyzed directly on the field on the following morphological characters: the mean length of the 3 longest side branches, number of fruits per plant, total weight of fruits.

The yellow fruits collected for seeds every week, were placed in a dry room, placed on the paper, then after a week, their seeds were extracted, rinsed in water and dried on the paper. After that, all collected seeds were weighed and used for the germination test.

It included germination test of the collected seeds and was carried out following the routine method described in the ISTA rules (Anonymous, 2012). For each treatment (plants tied to the sticks or creeping on the ground), 3 times 100 seeds were selected. All of them were dry, well developed and came from the 3 earliest harvests.

3.3 Chemical analysis

3.3.1 Evaluation of the dry matter. First, 5 g of the sample was pulverized to powder. Then, a smaller sample of 3 g was taken. The powder was placed into vessels and dryer at 130 ℃ for 2 h. Then, the vessels with a powder were cooled down till the weight was stable. The dry matter (x) was calculated using following the formula:

$$x(\%) = \frac{(a-c)}{(b-a)} \times 100$$

where a denotes weight of empty vessel (g), b denotes weight of vessel with a sample (g), and c denotes weight of vessel with a sample after drying (g).

3.3.2 Evaluation of the total protein. It was done following the Kjeldhal's method. First, 0.5 g sample was selected. Then, the catalyst was used: 3.5 g of K_2SO_4 and 0.4 g of $CuSO_4$ and H_2SO_4.

The blind sample was done with 15 mL of H_2SO_4. Then, the sample was burnt down into the stove of the company Buchi then mineralization took place at 180 ℃ for one hour. The sample was then balanced chemically with 0.1 M HCL. The total protein content (x) in the sample was calculated using following the formula:

$$x = \frac{(a-b) \times 6.25 \times 0.014 \times 100 \times n}{c}$$

where x denotes total protein content (%), a denotes amount of HCL used for the balancing sample (mL), b denotes amount of HCL used for balancing blind sample, c denotes the weight of sample (g); n denotes 0.1 (0.1 n HCL), and 6.25 denotes the calculation rate of N into protein.

3.4 Statistical evaluation of the data The variance was calculated. The significant differences were calculated based on the Duncan's test for $\alpha = 0.05$. The means with significant differences were marked with different letters.

4 Results and analysis

4.1 Seed germination If the plants were tied to the sticks, their fruits ripened earlier, and the seed germinated better than from the plants creeping on the ground. There was a big fluctuation of the received individual results of the seed germination tests, *i. e.* from 2% to 39%. The main reason for low germination of the seed was high number of dead seeds. It was not affected by the number of abnormal seedlings (Fig. 2).

When the seeds came from the first 3 harvests, they geminated from 2% to 39% (Table 1). The number of abnormal seedlings hesitated from 11% to 27%, whereas the number of dead seeds hesitated from 48% to 87%. When the seeds came from the second 3 harvests, they geminated from 8% to 56%. The number of abnormal seedlings hesitated from 0% to 6%, whereas the number of dead seeds hesitated from 38% to 92%.

The experiment proved that neither way of the production nor time of the harvest had an effect on the final germination of the seeds.

Table 1 Effects of cultivation methods of bitter gourd on seed germination of their first and second 3 harvests %

Cultivation method		First 3 harvests				Second 3 harvests			
		Replication			Mean	Replication			Mean
		1	2	3		1	2	3	
Tied to the sticks	Normal seedlings	17	15	39	23.7[a*]	26	24	56	35.3[a]
	Abnormal seedlings	13	18	27	19.3	6	4	6	5.3
	Dead seeds	48	68	54	56.7	68	72	38	59.3
Creeping	Normal seedlings	2	2	21	8.3[a]	22	8	12	14.0[a]
	Abnormal seedlings	13	11	12	12.0	0	0	1	0.3
	Dead seeds	85	87	67	79.7	78	92	86	85.3

Note: * denotes no significant difference according to the Duncan's test for $\alpha = 0.05$.

Note: A. normal seedlings from plants tied to the sticks, B. abnormal seedlings from plants tied to the sticks, C. normal seedlings from plants creeping on the ground, D. abnormal seedlings from plants creeping on the ground.

Fig. 2 Normal and abnormal seedlings received in the germination test on the bitter gourd seeds from the first 3 harvests

4.2 Seeds planting A good transplant should have the height of 7 cm, 3 leaves with the biggest one of 5.3 cm wide (Fig. 3). When the plants of bitter gourd were grown creeping on the field, they had longer side branches than the ones tied to the sticks (Table 2). However, it had a negative effect on the amount of available for the plants light and earliness of the creeping fruits. The number of fruits per plant in the bitter gourd plants grown in 2 ways varied and was bigger for the plants creeping on the field (Table 3). It was 3 times more than that for the plants tied with sticks.

Fig. 3 A well grown seedling of bitter gourd

Table 2 Effects of cultivation methods of bitter gourd on their 3 longest side branches length cm

Cultivation method	Replications	Individual measurements					Mean value	Value
		1	2	3	4	5		
Creeping on the field	1	241.7	252.7	261.3	233	204.3	238.6	229.5[a*]
	2	226.0	209.7	233.3	245.3	199.3	222.7	
	3	228.3	246.0	257.0	188.7	235.3	231.1	
	4	229.3	214.0	214.0	233.7	236.0	225.4	
Tied to the sticks	1	164.3	171.3	184.3	179.7	182.0	176.3	175.8[b]
	2	164.3	192.3	179.0	188.0	162.0	177.1	
	3	176.0	171.0	164.3	186.0	179.0	175.3	
	4	186.3	173.7	175.0	172.3	164.3	174.3	

Note: * denotes a given temperature not significantly different according to the Duncan's test for $\alpha = 0.05$. The same as below.

4.3 Fruits The total fruit weight per plant when the bitter gourd plants were creeping on the field was bigger than the one on the plants tied with sticks (Table 4). It was about 5 times bigger than that from the plants tied with sticks, it came from the effect

on the plants creeping on the field from the very beginning had higher number of flowers, longer side branches, better growth and then higher number of fruits.

The average fruit weight from the plants creeping on the field was bigger than that from the plants tied with sticks (Table 5). Because the plants were bigger and longer, so they had bigger number of flowers.

Table 3 Effects of cultivation method of bitter gourd plants on the number of fruits per plant received from the 5 biggest plants Pcs

Cultivation ways	Replications	Individual measurements					Mean value	Value
		1	2	3	4	5		
Creeping on the field	1	10	14	15	23	17	16	18.3[a**]
	2	20	15	29	25	16	25	
	3	28	22	10	7	23	18	
	4	14	13	10	17	14	14	
Tied to the sticks	1	8	10	6	6	10	8	5.0[b]
	2	4	4	5	4	5	4	
	3	3	2	5	4	2	3	
	4	4	7	4	6	4	5	

Table 4 Effects of cultivation method of bitter gourd on their total fruit weight per plant g

Cultivation ways	Replications	Individual measurements					Mean value	Value
		1	2	3	4	5		
Creeping on the field	1	542.9	608.2	809.5	1 320.8	716.9	799.7	872.3[a**]
	2	1 228.2	1 073.4	1 683.8	1 030.0	1 284.6	1 260.0	
	3	1 175.7	955.8	506.3	339.7	728.6	741.2	
	4	707.2	693.4	427.5	857.9	760.1	688.2	
Tied to the sticks	1	300.2	487.9	236.7	210.9	389.8	325.1	182.8[b]
	2	143.6	156.9	138.5	149.9	145.1	147.2	
	3	111.2	78.9	118.5	133.7	71.8	89.7	
	4	173.1	193.8	185.8	170.1	143.2	169.0	

Table 5 Effects of cultivation method of bitter gourd on their average fruit fresh weight g

Cultivation ways	Replications	Individual measurements					Mean value	Value
		1	2	3	4	5		
Creeping on the field	1	54.3	43.4	54.0	57.4	42.2	50.3	49.4[a**]
	2	61.4	71.6	58.1	41.2	35.7	53.6	
	3	42.0	43.4	50.6	48.5	31.7	43.2	
	4	50.5	53.3	42.8	50.5	54.3	50.3	
Tied to the sticks	1	37.5	48.8	39.5	35.2	39.0	40.0	36.0[b]
	2	35.9	39.2	27.7	37.5	29.0	33.9	
	3	37.1	39.5	23.7	33.4	35.9	33.9	
	4	43.3	27.7	46.5	28.4	35.8	36.3	

4.4 Chemical composition The dry matter content in the tested fruits hesitated from 88.7% to 91.9% (Table 7). The used production way had no effect on the dry matter content of the fruits. The magnesium (Mg) content in the tested fruits hesitated from 175.9% to 258.8% (Table 6). The used production way had no effect on the magnesium (Mg) content of the fruits. The calcium (Ca) content in the tested fruits hesitated from 292.9% to 454.8%. The used production way had no effect on the calcium (Ca) content of the fruits.

The fat content in the tested fruits hesitated from 0.9% to 3.7% (Table 7). The production way had no effect on the fat content of the fruits. The protein content in the tested fruits hesitated from 9.3% to 14.8% (Table 8). The production way had no effect on the protein content of the fruits. The carbohydrate content in the tested fruits hesitated from 63.1% to 68.2% (Table 7). The production way had no effect on the carbohydrate content of the fruits. The iron (Fe) content in the tested fruits hesitated from 4.4% to 5.5% (Table 9). The production way had no effect on the iron (Fe) content of the fruits. The manganese (Mn) content in the tested fruits hesitated from 1.0% to 2.3% (Table 8). The production way had no effect on the manganese (Mn) content of the fruits. The zinc (Zn) content in the tested fruits hesitated from 2.0% to 3.2% (Table 10). The used production way had no effect on the zinc (Zn) content of the fruits. The copper (Cu) content in the tested fruits hesitated from 0.5% to 0.7% (Table 9). The production way had no effect on the copper (Cu) content of the fruits. The ashes content in the tested fruits hesitated from 8.5% to 10.0% (Table 10). The production way had no effect on the ashes content of the fruits.

Table 7 Effects of cultivation method of bitter gourd on the content of dry matter, Mg and Ca in their fruits

Chemical element	Creeping on the field			Tied to the sticks		
	Replication		Mean value	Replication		Mean value
Dry matter//%	1	91.1	90.0[a]	1	89.5	89.8[a]
	2	88.7		2	89.9	
	3	90.3		3	89.9	
Mg//mg/100g d. w.	1	209.6	227.3[a]	1	201.1	194.1[a]
	2	258.8		2	205.2	
	3	213.4		3	175.9	
Ca//mg/100g d. w.	1	336.3	361.3[a]	1	314.5	330.0[a]
	2	454.8		2	323.6	
	3	292.9		3	351.9	

Table 8 Effects of cultivation method of bitter gourd on the content of fat , protein and carbohydrate in their fruits %

Cultivation method	Creeping on the field			Tied to the sticks		
	Replication		Mean value	Replication		Mean value
Fat	1	1.9	2.2[a]	1	1.4	2.2[a]
	2	0.9		2	2.4	
	3	3.7		3	2.7	
Protein	1	12.3	12.1[a]	1	11.7	11.9[a]
	2	14.8		2	10.8	
	3	9.3		3	13.1	
Carbohydrate	1	67.0	66.1[a]	1	67.6	66.3[a]
	2	63.1		2	66.6	
	3	68.2		3	64.6	

Table 9 Effects of cultivation method of bitter gourd on the content of Fe and Mn in their fruits

Cultivation method	Creeping on the field			Tied to the sticks		
	Replication		Mean value	Replication		Mean value
Fe// mg/100g d. w.	1	5.5	5.0[a]	1	4.8	4.8[a]
	2	5.1		2	4.4	
	3	4.5		3	5.1	
Mn//mg/100g d. w.	1	1.6	1.8[a]	1	1.2	1.1[a]
	2	2.3		2	1.2	
	3	1.5		3	1.0	

Table 10 Effects of cultivation method of bitter gourd on the content of Zn, Cu and ashes in their fruits

Chemical element	Creeping on the field			Tied to the sticks		
	Replication		Mean value	Replication		Mean value
Zn//mg/100g d. w.	1	2.6	2.6[a]	1	2.2	2.3[a]
	2	3.2		2	2.4	
	3	2.0		3	2.4	
Cu//mg/100g d. w.	1	0.7	0.6[a]	1	0.6	0.6[a]
	2	0.7		2	0.6	
	3	0.5		3	0.5	
Ashes//%	1	10.0	9.8[a]	1	9.8	9.1[a]
	2	9.9		2	9.1	
	3	9.5		3	8.5	

5 Conclusions

In the climatic conditions of Europe, it is possible to grow bitter gourd in the field and produce its seeds. For the early cultivars, the vegetation period is longer enough to set germinating seeds. The best transplants of bitter gourd were received within one month from the seeds germinating 51.8%. The transplant of bitter gourd was 7 cm high, had 3 – 4 leaves, out of which the best had width of 5 cm. Such transplants developed into fruiting plants. When growing bitter gourd for seeds, the earliest harvest of fruits was received from the plants tied to the sticks. Moreover, the best seeds were received from 2/3 of early fruits. For this reason, it is suggested to keep only 3 – 4 fruits per plant, and remove other fruits. The bitter gourd produced in the European climatic conditions had bitter gourd seeds germinated from 8% to 24%. If the plants were tied to the sticks, their fruits ripened earlier than when creeping on the field. The production way and time of harvest of fruits used in the experiment had no effect on the seed germination. The cultivation method of bitter gourd plants had no effect on their fruits' chemical content.

6 Discussions

In the past 50 years, seed sector has been developing dynamically. Nowadays, there is still no sign of any crisis in it[14]. Recently, especially interesting trend in this area has been so-called functional food, *i. e.* food which could both feed and cure people[15]. Bitter gourd meets this definition. The importance of bitter gourd in the world has been increasing. It is so, because we are still getting new information about possibilities of using its new parts in curing people[10].

Cucurbittaceae is one of the largest families in vegetable kingdom consisting of largest number of edible type species. Bitter gourd is one such important vegetable that belongs to the family of Cucurbitaceae[16]. It is used in the world not only as a food, but at the same, as affective functional food[17] and source of some enzymes for cleaning water[18].

The best transplants of bitter gourd were received within a month from the seeds germinating 51.8%. The transplant of bitter gourd was 7 cm high, had 3 – 4 leaves, out of which the best had width of 5 cm. Such transplants developed into fruiting plants.

When growing bitter gourd for seeds, the earliest harvest of fruits was received from the plants tied to the sticks. Moreover, the best seeds were received from 2/3 of early fruits. For this reason, it is suggested to keep only 3 – 4 fruits per each plant. The other fruits should be removed. This is in agreement with the results of experiments described for cucumber reported by Korohoda (1974) and George (1985). The cultivation method of bitter gourd plants had no effect on their seed germination and their fruits' chemical content.

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be silent, resulting in the psychology of relying on the teacher's answers. After adopting the task-driven teaching method, every member of the group has to participate in the task explanation, and the participation of students is greatly increased. It is not only the teachers standing on the podium, the learning atmosphere has become active, and the learning enthusiasm has also been significantly improved.

Finally, through the investigation of the students involved in the research, they generally speak highly of the task-driven teaching method. They believe that compared with the traditional teaching method, task-based teaching method improves the initiative of learning. When they encounter difficult problems, they will take the initiative to search for information, which in itself is a way to cultivate learning ability. Second, it cultivates the ability to find and solve problems. In the process of solving the problem, they also learned a variety of cutting-edge knowledge related to the course. Third, it strengthens the sense of unity and cooperation among students and strengthens the cohesion.

4 Conclusions and discussions

Taking *Introduction to Land Engineering* as an example, this study applies task-driven teaching method and traditional teaching method to classroom teaching. The results show that compared with the traditional teaching method, the task-driven teaching method has obvious advantages. Whether in terms of students' attendance rate, participation or learning enthusiasm, it is better than the traditional method. Besides, it also reflects that the teaching is student-oriented, realizes the concept of quality education, and fully demonstrates its superiority in the teaching of land engineering. However, there are several points that need to be paid attention to. First of all, the classroom tasks should be evenly distributed in terms of important and difficult points. Second, the assignment of tasks should not be too rigid or too flexible. It is necessary to arouse the enthusiasm of students as much as possible and give full play to the spirit of group cooperation. Finally, when the students become the main body of the classroom, the lecturer should also pay attention to controlling the classroom schedule. In the explanation, when students encounter problems, the lecturer should give guidance, remind and correct them in time.

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