USE OF PERT (PROGRAM EVALUATION AND REVIEW TECHNIQUE) AND PDM (PRECEDENCE DIAGRAMMING METHOD) IN ORGANIZING MODERN VEGETABLE SEEDLING PRODUCTION

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A B S T R A C T

Propagation of quality vegetable seedlings is a key of successful vegetable production in an open field and in protected areas. The research is aimed at the production process itself, analyzing it from technological and organizational aspects. Based on a detail calculation of time, means and costs, the researchers obtained the duration of production in days, regarding the propagation of pepper, tomato, cabbage and lettuce seedlings, taking into consideration different technological requirements of crops, ripening time, delivery time and an optimal use of the propagation area. The use of the Program Evaluation and Review Technique required more attention when making a production plan, resulting in the introduction of activities, the realization of which required only the flow of time to harmonize the monitoring of real activities. By using the Precedence Diagramming Method this problem was overcome with predefining the type of relationship between the interdependent activities (Finish-to-Start, Finish-to-Finish, Start-to-Start, and Start-to-Finish).

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Introduction

One of the characteristics and specificities of vegetable production and vegetable seedlings outdoors is their seasonal character and mismatch in time of performing operations and time of production. Nevertheless, when it comes to indoor production, especially regarding the

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implementation of modern production technologies, production processes can be planned and adjusted more precisely. Like in outdoor production, indoor production requires more even use of capacities due to the fact multiple vegetable crops are grown at the same time. Adjusting and complementing the indoor production of several vegetable crops allows us to make full use of labor and means of production during most part of the year or all year round. It should be noted here that the structure of clients (farmers and other subjects) significantly affects the structure of production, depending on the production system (outdoor or indoor) and time of procuring quality seedlings.

Agritourism has received growing academic attention over the recent decades (Rokvić Knežić et al., 2020; Dimitrovski et al., 2021). From the aspects of yields, net profits and work productivity in agriculture, vegetable production is one of the most intensive part of plant production, providing 5 to 8 times higher value of outdoor production than wheat outdoor production, and 190 to 250 times higher value of indoor production (Vlahović et al., 2010; Milojević et al., 2020). Quality seedlings are a key to successful vegetable production, both in open fields and in protected areas (Moravčević, 2015). Demand is met with imports, since the domestic market is generally undeveloped and production of quality seedlings in Serbia is at low levels. Although the company in question has relatively modern glasshouse and technology, most of the highest quality seedlings of fruiting vegetables are imported from Hungary, Greece, and even from Bosnia and Herzegovina (Ilin et al., 2002).

Another part of the market comprises small domestic companies that seldomly produce seedlings for larger, specialized vegetable producers, but are mostly aimed to semi-commercialized farms and hobbyists who produce vegetables for their families in their yards. The largest part of commercial vegetable production, of course, is based on on-farm production of seedlings. Such farmers have put great effort lately to improve production technologies, by investing considerable amounts of money in heated facilities and fewer amounts in modern equipment.

The subject-matter of the research is organizational and technological aspects of production process in an organization that produces quality vegetable seedlings. The research was aimed at the production process itself, analyzing it from technological, organizational and economic aspects. The technological and organizational segment is the part that needs and can be improved and intensified to strengthen a competitive position and achieve production sustainability. The research was carried out in an organization that is categorized as a small and medium enterprise (SME). A modern approach to seedling production resulted from research has proved to be an adequate for implementation within SMEs, since it requires significant investments and expert knowledge. Small and medium enterprises are the ones acknowledged by the European Commission as the main business entities that encourage development and employment (EC, 2003). In Serbia, after the period of transition, this form of business entity has been confirmed as the most efficient economic segment and later, even until today, as a carrier of economic growth and development (Erić et al., 2012).

Nowadays, there are modern forms of managing agricultural production that considerably facilitate and speed up the managing process itself and making important decisions in a timely manner. In agricultural production, and especially in vegetable production, network planning is successfully used. Along with modern and practically proved software solutions, it allows permanent monitoring of the production process, making the most important information available at every moment, and enabling changes in the existing working processes in order to achieve more rational production. Network models, being at the same time mathematical models, apart from providing a visual overview of activities, also provide clients with a detailed analysis of project time and cost components. A network diagram or a network plan is a kind of a dynamics plan that graphically displays the dynamics of activities within a project. The activities are interlinked depending of a logical sequence, paths and time of realization, depending of a production technology. By making a network diagram, one can create a logical structure of project realization, an overview of a detailed analysis of time of realization of all activities and a project in general (Radulović et al., 1988).

Materials and methods

The methods applied in this research had been adjusted to the subject-matter and the goal of the research. The subject-matter was the production process of obtaining quality vegetable seedlings from peat blocks. Given that the subject-matter can be seen as one system, the researchers used the method of a study case as the main methodological framework. The focus of the research was put on technological and organizational aspects of the production process. This method was efficient for analyzing the dynamics of the organization that was determined by many criteria of technological, organizational, and economic character, as well as other internal and external factors. Having a thorough approach in analyzing causes and effects of the activities within the production process, the researchers dug into the operational dynamics and came to the essence of the relationships between the elements of the system.

A methodological basis of the research was a detailed calculations of performance rates of the production machine and human labor when sowing in peat blocks, calculated based on chronometric and chronographic recording of the whole operation. Two methods of network planning were used: PERT module of “WinQSB” and PDM of “MS-Project 2013”.

The characteristics of technological process, the structure of production, product characteristics, duration of certain stages of production and production capacity are the elements that define an organizational approach in terms of dynamics, use of resources, time and production capacity. During the research, the methods and techniques of project and process management were used, putting their focus on saving resources timewise and material wise, calculating slack, analyzing capacities and identifying bottlenecks in the process of production, creating network diagrams and Gantt charts, namely, monitoring the flexibility, efficiency and dynamics of the whole flow of production (Jovanović, 2015; Pantić et al., 2021). All factors of the production process were taken into consideration, making a reliable foundation for quality process of synthesis.

In this research, PERT (Program Evaluation and Review Technique) and PDM (Precedence Diagramming Methods) were used, but the preference was shown to PDM, due to certain advantages this method gives in terms of time distribution between the activities (Lock, 2007), which the author had studied by using the techniques in question when making a plan of spring operations for multiple field crops (Ljiljanic et al., 2016). Moreover, PDM allows additional flexibility during process modeling (Wiest, 1981; Radić et al., 2020). PDM is a prevailing method of network planning nowadays. Its continuous use is based on the flexibility of its models compared to other techniques, and an easily understandable mathematical model in the background (Hajdu, 2015).

Results with discussions

A model of technological and organizational plan of production was composed for a business entity with modern production of vegetable seedlings: pepper, tomato, cabbage and lettuce seedlings. The following factors were taken into consideration when composing the technological and organizational plan: (1) the enterprise in question had a highly sophisticated heated glasshouse and systems for nutrition and irrigation. Production area was 10,000 m^2 and its utilization depends on the time of the year, demand for a particular commodity and the client's profile in terms of good business practice. (2) Within the glasshouse, the enterprise had an office where the production line were situated, together with machines. Furthermore, there was a germination chamber in one part of the glasshouse. The production lines had enough production capacities for utilizing all the working area in case that the maximum capacities are required to be put in use. (3) Five was the optimal number of workers during the sowing to use the machines and put the crates into the germination chamber. (4) The seedlings were produced by using the peat blocks technology. The enterprise produced pepper, tomato, cabbage and lettuce seedlings. A peat blocks machine made by Unger, a German manufacturer, prepares blocks of different size for different vegetable crops. Uniform crates (size 42cm x 62cm) were used, in which different number of blocks of different size (7cm, 6cm, 5cm, 4cm and "speedy") can fit for a certain number of crops. When it comes to occupation of the working area, three crates could fit in 1 m^2. This information was very important from the aspect of planning and production limit one should have in mind. (5) The operations carried out in the process of obtaining the end products were seeding, germination and propagation.

The germination stage is carried out in the germination chamber with controlled humidity and temperature of air. The germination of peppers and tomatoes requires the temperature of 25 ^{0}C, lettuce 18-20 ^{0}C and cabbage 16 ^{0}C. This means that the germination chamber can hold only tomatoes and peppers at the same time, while cabbage and lettuce have to be germinated separately. It is an important thing to consider when planning the whole process.

The plan of organization of production, making of which included all the aforementioned factors, was described in detail through the following activities: (1) Activity "A"-Lettuce – Sowing of lettuce. Sowing begins on 1 Nov 202X and lettuce is sown in

4 cm peat blocks. The number of plants to be sown is 2,100,000, which is 15,000 uniform crates, occupying 5,000 m^2 of the propagation area. Time needed for sowing by machinery is 7.73 days. (2) Activity “B”– Lettuce - Germination. The process of germination begins when the chamber is filled up with crates after sowing is finished for that day. The chamber is then set on the appropriate humidity and temperature. It is filled up successfully, day by day, as long as the sowing takes place. Given that sowing lasts for less than eight days, and germination for two days, after two days the crates started to be moved to the area for propagation and the propagation process starts. The germination of all 2,100,000 plants lasts for nine days. (3) Activity “C” – Lettuce - Propagation. The propagation starts when the germination is finished and the plants are ready to be placed out of the chamber. This process last for 25 days. It starts two days after the germination process begins. The working area is successively filled out and it will be 50% occupied in the next nine days after the germination is completely finished. (4) Activity “D”– Cabbage - Sowing. The sowing of cabbage begins on 1 Dec 202x and it is sown in 7cm peat blocks. The number of plants to be sown is 600,000, in 15,000 crates, occupying 5,000 m^2 of the propagation area. Time needed for sowing is 3.03 days. (5) Activity “E” – Cabbage - Germination. The process of germination begins when the chamber is filled up with crates after sowing is finished for that day. The chamber is filled up successively for three days. Given that the sowing lasts for 3.03 days and germination for two days, after two days the crates started to be moved into the propagation area and the propagation starts. This activity lasts for 5 days. (6) Activity “F” – Cabbage - Propagation. The process begins after the germination is finished and the plants are ready to be moved out of the chamber on the propagation area. It lasts for 55 days. The process of propagation starts two days after the beginning of germination, by successively filling out the propagation area. The total duration of this activity is 59 days. (7) Activity “G” – Peppers – Sowing. The sowing begins on 8 Jan 202X+1 and peppers are sown in 7 cm peat blocks. The number of plants to be sown is 300,000, in 7,500 crates, occupying 2,500 m^2 of the propagation area. Time needed for sowing is 1.52 days. (8) Activity “H” – Peppers – Germination. The process of germination starts right after the sowing, when the chamber is filled up with the crates. The chamber is filled successively. Given that the sowing lasts for 1.52 days and germination for 7 days, after 7 days the crates are started to be moved into the propagation area and propagation starts. The total duration of this activity is 8.53 days. (9) Activity “I” – Peppers – Propagation. The process of propagation starts after germination is finished and the plants are ready to be taken out of the chamber. It lasts for 56 days. The process of propagation starts 7 days after the germination and the propagation area is successively filled out. The total duration of this activity is 63 days. (10) Activity “J” – Tomatoes – Sowing. The sowing of tomatoes starts on 09 Jan 202X+1, right after the sowing of peppers. Tomatoes are sown in 7 cm peat blocks. This is an example of technological compatibility of peppers and tomatoes in terms of their germination, which allows you to continue with sowing tomatoes right after peppers. The number of plants to be sown is 300,000, in 7,500 crates, occupying 2,500 m^2 of the propagation area. Time needed for sowing is 1.52 days. (11) Activity “K”

– Tomatoes – germination. The process of germination starts right after the sowing, when the chamber is filled up with the crates. The chamber is filled up successively. Given that the sowing lasts for 1.52 days and germination for 4 days, after 4 days the crates are started to be moved into the propagation area and the propagation starts. The total duration of this activity is 5.52 days. (12) Activity "L" – Tomatoes – Propagation. The process of propagation begins after germination and moving the plants out of the chamber into the propagation area. It lasts for 42 days. The process starts 4 days after the beginning of germination. The propagation area is filled out successively. The total duration of this activity is 46 days. (13) Activity "M" – Peppers – Sowing. The sowing begins on 01 Mar 202X+1 and in this period, peppers are sown in 5 cm peat blocks. The number of plants to be sown is 720,000, in 7,500 crates, occupying 2,500 m^2. Time needed for sowing is 2.69 days. The sowing can start right after the tomato propagation is finished. (14) Activity "N" – Peppers – Germination. The process of germination starts right after the sowing, when the chamber is filled up with the crates. The chamber is successively filled up with crates. Given that the sowing lasts for 2.69 days and germination 7 days, after 7 days the crates are started to be moved into the propagation area and the propagation starts. The total duration of this activity is 8.69 days. (15) Activity "O" – Peppers – Propagation. The process of propagation starts after the germination is finished and the plants are ready to be taken out of the chamber. It lasts for 49 days. The process of propagation starts 7 days after the germination begins and the propagation area is successively filled out. The total duration of this activity is 56 days. (16) Activity "P" – Tomatoes – Sowing. The sowing of tomatoes starts on 05 Mar 202X+1. Tomatoes are sown in 7 cm peat blocks. The number of plants to be sown is 300,000, in 7,500 crates, occupying 2,500 m^2 of the propagation area. Time needed for sowing is 1.52 days. The sowing starts when the propagation area starts clearing out from peppers. (17) Activity "Q" – Tomatoes – Germination. The process of germination begins right after the sowing, when the chamber is filled up with the crates. The chamber is filled up successively. Given that the sowing lasts for 1.52 days and germination for 4 days, after 4 days the crates are moved out into the propagation area. The total duration of this activity is 5.52 days. (18) Activity "R" - Tomatoes – Propagation. The process of propagation starts after the germination, when the plants are ready to be taken out of the chamber into the propagation area. It lasts for 42 days. The propagation process starts 4 days after the beginning of germination and the propagation area is successively filled out with plants. The total duration of this activity is 46 days. (19) Activity "S" - Cabbage - Sowing. The sowing begins on 21 Mar 202x+1and cabbage is sown in "speedy" peat blocks. The number of plants to be sown is 8,100,000, in 15,000 crates, occupying 5,000 m^2 of the propagation area. Time for sowing is 9.14 days. (20) Activity "T" - Cabbage - Germination. The process of germination starts right after the sowing, when the chamber is filled up with the crates. The chamber is successively filled up with crates for three days. Given that the sowing lasts for 9.14 days and germination for 2 days, after 2 days the crates are moved into the propagation area. The total duration of this activity is 10.14 days. (21) Activity "U" - Cabbage - Propagation. The process of propagation starts after the germination is finished and the plants are ready to be taken out of the chamber. It lasts for 36 days. The recess of propagation starts 2 days after the beginning of germination and the propagation area is successively filled out. The total duration of this activity is 46 days.

All methods of network planning have certain advantages and disadvantages in terms of their implementation into various projects with different technological and organizational requirements, as well as results the person wants to achieve. In this research, processes are predominant, i.e. activities duration of which cannot be fixed with certainty, primarily when it comes to the duration of seed germination and propagation of seedlings for different vegetable crops. Therefore, the researchers used the PERT method. Factors that affect duration of the activities are technological, and depend on the type of seeds, hybrids, and oscillations in temperature, light, precision during the application of crop nutrients and crop protection chemicals, etc. PERT was chosen since it took into consideration how uncertain was to estimate the amount of time certain operations in the technological and organizational plan required, due to various factors that can affect their duration. Since it is not possible to determine precisely the duration of certain activities, it is estimated by using statistical methods, and in this research by using experience estimating methods, based on the use of different hybrid seeds of vegetable crops (Ceranić, 2009).

Figure 1 shows the activities in a technological and organizational plan of seedling propagation. It shows the most probable, optimistic and pessimistic duration of all activities. If the activities were carried out successively, one after another, propagation would last for 570.90 days. Some of the activities were nevertheless carried out simultaneously, while other could start when some other activities are finished.

Having analyzed the model by using the WinQSB software, the following parameters were obtained: the sequence of activities, critical activities, duration of activities, the earliest start and finish of activities, the latest start and finish of activities, slack, standard deviation, number of critical paths, and most importantly, duration of the propagation process.

The total of 41 activities are shown and all of these are real-life activities. 21 of them reflects the work process that requires means and time (A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T and U). It was necessary to introduce 20 activities in terms of time flow, to meet the technical requirements of the software and obtain a precise estimation of duration and deadlines of the activities (a1, b1, c1, d1, e1, f1, g1, g2, h1, i1, j1, k1, l1, m1, n1, p1, q1, s1 and t1). The duration of the whole process of seedling propagation was 188.00 days, which is 382.9 days shorter than in case of carrying out activities successively, one after another. Furthermore, there is a critical path consisting of critical activities - activities whose slacks (Slack (LS-ES)) equal zero, which means there are no improvisations in terms of time of their realization, and they have to be carried out at the exact time.

Figure 1. The solution of the aforementioned problem given by the PERT method, WinQSB

02-21-2022 00:15:12	Activity Name	On Critical Path	Activity Mean Time	Earliest Start	Earliest Finish	Latest Start	Latest Finish	Slack (LS-ES)	Activity Time Distribution	Standard Deviation
10	e1	Yes	2	31	33	31	33	0	3-Time estimate	0.0333
11	F	no	59	33	92	129	188	96	3-Time estimate	1.6667
12	f1	Yes	35	33	68	33	68	0	3-Time estimate	0.3333
13	G	no	1.5133	68	69.5133	71.2867	72.8	3.2867	3-Time estimate	0.05
14	g1	Yes	1	68	69	68	69	0	3-Time estimate	0.0333
15	g2	no	47	69.5133	116.5133	90.8	137.8	21.2867	3-Time estimate	0.6667
16	H	no	8.5133	69	77.5133	179.4867	188	110.4867	3-Time estimate	0.5
17	h1	Yes	7	69	76	69	76	0	3-Time estimate	0.0333
18	I	Yes	63	76	139	76	139	0	3-Time estimate	0.6667
19	i1	Yes	1	139	140	139	140	0	3-Time estimate	0.0333
20	J	no	1.5133	69.5133	71.0267	186.4867	188	116.9733	3-Time estimate	0.05
21	j1	no	0.2	69.5133	69.7133	72.8	73	3.2867	3-Time estimate	0.0167
22	K	no	5.43	69.7133	75.1433	182.57	188	112.8567	3-Time estimate	0.25
23	k1	no	4	69.7133	73.7133	73	77	3.2867	3-Time estimate	0.1667
24	L	no	46	73.7133	119.7133	77	123	3.2867	3-Time estimate	0.6667
25	l1	no	1	119.7133	120.7133	123	124	3.2867	3-Time estimate	0.0333
26	M	no	2.1633	120.7133	122.8767	185.8367	188	65.1233	3-Time estimate	0.05
27	m1	no	1	120.7133	121.7133	124	125	3.2867	3-Time estimate	0.0333
28	N	no	8.23	121.7133	129.9433	179.77	188	58.0567	3-Time estimate	0.4833
29	n1	no	7	121.7133	128.7133	125	132	3.2867	3-Time estimate	0.1667
30	O	no	56	128.7133	184.7133	132	188	3.2867	3-Time estimate	0.6667
31	P	no	1.5133	116.5133	118.0267	186.4867	188	69.9733	3-Time estimate	0.05
32	p1	no	0.2	116.5133	116.7133	137.8	138	21.2867	3-Time estimate	0.0167
33	Q	no	5.43	116.7133	122.1433	182.57	188	65.8567	3-Time estimate	0.25
34	q1	no	4	116.7133	120.7133	138	142	21.2867	3-Time estimate	0.1667
35	R	no	46	120.7133	166.7133	142	188	21.2867	3-Time estimate	0.6667
36	S	no	9.1433	140	149.1433	178.8567	188	38.8567	3-Time estimate	0.05
37	s1	Yes	1	140	141	140	141	0	3-Time estimate	0.0333
38	T	no	11.1433	141	152.1433	176.8567	188	35.8567	3-Time estimate	0.05
39	t1	Yes	2	141	143	141	143	0	3-Time estimate	0.0333
40	U	Yes	45	143	188	143	188	0	3-Time estimate	1.6667
	Project	Completion	Time	=	188	days				
	Number of	Critical	Path(s)	=	1					

Source: WinQSB

At the time of making the production plan by using the "MS Project 2013" software and the network diagram, all the preconditions for using the precedence method were met. The Precedence Diagramming Method is used in project management since it is highly applicable when using computer technology and software (PMBOK Guide, 2013). The activities in network diagrams are shown in boxes, and logical relationships between them are indicated with arrows. This method is also called "AON" (Activity on Node) and it is a method that most project management software, as "MS-Project", use to generate the network model (Slack et al., 2007). There are four types of activity relationships, "FS" (*Finish to Start*) – the previous activity must finish before the next activity starts; "FF" (*Finish to Finish*) – the previous activity must finish before the next activity can finish; "SS" (*Start to Start*) – the previous activity must start before the next activity can start; "SF" (*Start to Finish*) – the previous activity must start before the next activity finishes.

In order to plan production precisely and to adjust it to meet clients' requirements, in terms of quantity and quality but also delivery time, it is highly important to know all the aspects of production technologies, production and machine capacities and labor availability. Knowing the aforementioned elements of the production process in detail enables the determination of the types of relationships between certain activities. There are 15 "SS"-relationships in the aforementioned example, indicating that a key thing for their setting-up is to know the technology of production and use of the same resources in terms of production. "FS" relationships, and there is three of them in the aforementioned example, are conventional by their nature, representing logical relationships in the sequence of carrying out the activities. Nevertheless, taking into consideration the software and the production plan, as well as the network diagram that is updated each time activity data are completed, it is clear that both "SS" and "FS" types of relationships can be regarded as logical relationships in the sequence. Although there are no "FF" and "SF" relationships in the aforementioned example, they should be mentioned as the relationships that are closely related to knowing production technology before other criteria.

Table 1. Descriptions of activities, their interdependence and duration in days (PDM)

No.	Activity	Vegetable crop – activity description	Depends on the following activities	Type of interdependence	Duration of activities (in days)
1	A	Lettuce - sowing (01 Nov 202X)	none	none	7.73
2	B	Lettuce - germination	A	SS+2 days	9,00
3	C	Lettuce - propagation	B	SS+2 days	32.00
4	D	Cabbage - sowing (01 Dec 202X)	none	none	3.03
5	E	Cabbage - germination	D	SS+2 days	5.00
6	F	Cabbage - propagation	E	SS+2 days	59.00
7	G	Peppers - sowing (08 Jan 202X+1)	none	none	1,52
8	H	Peppers - germination	G	SS+1.52 day	8.52
9	I	Peppers - propagation	H	SS+7 days	63.00
10	J	Tomatoes - sowing (09 Jan 202X+1)	G	SS+0.1 day	1.52
11	K	Tomatoes - germination	J	SS+0.2 day	5.52
12	L	Tomatoes - propagation	K	SS+4 days	46.00
13	M	Peppers - sowing (01 Mar 202X+1)	L	FS+1 day	2.17
14	N	Peppers - germination	M	SS+1 day	8.17
15	O	Peppers - propagation	N	SS+7 days	56.00
16	P	Tomatoes - sowing (05 Mar 202X+1)	G	FS+55 days	1.52
17	Q	Tomatoes - germination	P	SS+0.2 day	5.52
18	R	Tomatoes - propagation	Q	SS+4 days	46.00
19	S	Cabbage - sowing (21 Mar 202X+1)	I	FS+1 day	9.14
20	T	Cabbage - germination	S	SS+1 day	11.14
21	U	Cabbage - propagation	T	SS+2 days	45.00

Source: Authors' calculations

If the whole process of seedlings propagation, all activities, are regarded as one successive "FS" sequence, the whole process would last for 426.5 days. By using PDM, the authors calculated that the process could last for 189 days, namely from 1 Nov 202X to 8 May 202X+1. During the whole period, the production process would not be interrupted, only the quantity and type of crops that go through the germination chamber and propagation area would change.

It is important to note that, according to Lock (2007), PDM gives certain advantages over PERT in terms of time distribution between the activities. One of the authors has already studied the application of these techniques when generating a plan of spring operations for multiple vegetable crops (Ljiljanic et al, 2016; Ceranić et al., 2015) and confirmed those advantages. Furthermore, PDM allows additional flexibility in process modelling (Wiest, 1981). PDM is a prevailing method used nowadays. A continuous use of this method is based on its flexibility over other available techniques and an easily understandable mathematical model in the background (Hajdu, 2015).

Conclusions

The production process is carried out constantly, only crops are changed, depending on the period of a year, market demands and natural (climate) conditions that dictate when the time production starts, outdoors and indoors. Within the production process there are groups of activities that are mostly conducted simultaneously. That is sowing, germination process and propagation, of all crops. Realization of these activities requires synchronization and integration of available means and labor. Time distribution is dictated by production traits of vegetable crops.

Prior to making a plan of seedling propagation of peppers, tomatoes, cabbage and lettuce, a detailed calculation was made of all processes, production capacities and labor. It was made based on the previous recording of all operations (chronography and chronometry) and the data on production traits of all vegetable varieties and hybrids of vegetables seedlings of which were propagated. The production conditions were strictly controlled in terms of humidity and temperature, so it was highly unlikely that this factor could prolong or shorten the production process.

Two methods of network planning were used – PERT and PDM and a network diagram and a Gantt chart were created. The PERT showed that the whole production process could last for 188.0 days, and PDM that the process could last for 189.0 days. PERT took into consideration the factor of uncertainty of evaluation time needed for carrying out the operations, and PDM helped creating the output documents (a network diagram, a Gantt chart) that allowed more detailed, more transparent, and a clearer visual overview and, consequently, more practical use of the document.

Both methods gave almost identical results. Nevertheless, what can be concluded is that PERT requires more precision when making a production plan, which resulted in implementing some activities the realization of which required only the necessary time flow in order to harmonize properly the monitoring of the activities that take time and money. It was not the case when using PDM, since this problem can be overcome by predefining the type of relationships between the interdependent activities (FS, FF, SS, and SF). From the Gantt chart made by "MS Project", one can clearly see the simplicity of using PDM. Furthermore, this method also stands out as flexible in making mathematical models and modelling possibilities, enabling you to change production parameters during the whole process and learn the end result of the use of the resources.

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Conflict of interests

The authors declare no conflict of interest.

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