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Possibilities of Rationalization of Perennial Plantation Establishment

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Abstract

The process of perennial plantation establishment represents a group of various working activities whose main goal is to come to an end in the optimal period in the frame of given resources. The solution to this project problem could be found by applying the CPM method of network planning. This is one of the newest ways of operative planning, which is characterized by high flexibility, so it can involve one or more working activities, in one day or during the whole season. This paper aims to analyze the possibilities of rational development of the process of ground preparation and plantation establishment, with minimal costs of limited resources. The methodological procedure is applied on the model of apple plantation.

Key words: *plantation establishment, network planning, time reserves*

JEL Classification: *Q19, Q10 , Q12*

Introduction

The establishment of perennial plantation is a very complex and responsible investment undertaking. It requires large investments, so organizational-economic, biotechnological, and other mistakes made in this period, can not be eliminated later, which implies many risks[1]. Besides the process of solving many questions, which are predicted by the investment project of plantation establishment, creation of various working activities realization plan is necessary. It is also required, that during an optimal period, on adequate areas, by involving the significant quantum of assets and labor, numerous elements should be synchronized and connected into a harmonious complex and in the coordination of all working units. Thus, the basic aim of the research presented in this paper is the validation of the optimal period needed for the realization of all processes of perennial plantation establishment, contingent on limited resources spending, or providing possibilities for time cutting of its realization with minimal costs.

Data Collection and Method of Research

In order to determine the starting factors in manuscript we have used data from the investment program and accounting evidence of apple plantation, which is located in Obrenovac, a town close to Belgrade. Analysing the working activities which are performed, and their time duration, it is created the projection of apple plantation on a total surface of 100 ha, for Pilar breeding type of

[1] S r e d o j e v i ć , Z, *Procena vrednosti višegodišnjih zasada.* Monografija. DAEJ i Ekonomski institut, Beograd. 1998.

cordon, with interline space 4x1 m. In order to set the norms for the working group's daily efficiency, planning of time and schedule of working activities are done according to the empirical data and experts' practical field estimations.

The solution of the project problem of apple plantation establishment is achieved by means of network planning technique, using the so-called CPM method (Critical Path Method). Taking care of specified rules in the above mentioned technique, according to a created list of activities and connections, the adequate network diagram is constructed. According to Fulkers' rules, numbering of all events is done. By the *forward – backward* procedure, estimation chart is designed, critical path or "bottle neck" of project realization is determined and all time reserves are accounted.

Research Results

Starting Parameters for Network Diagram Constructing

Working processes during apple plantation establishment are multiple, time and space dispersed and characterized by some specific features[2]. According to their organizational aspect, they are divided into preparatory and planting activities. For the plantation under analysis, the type of operation, the time period of their conduction, the number of days for some operations the, content and working efficiency of the working group, the total quantum of activities and the needed number of days for pursuing the complete project, are given in Table 1.

Table 1. Plan of activities during the apple plantation establishment – ground preparation and planting

No	Type of activity	Month of working	Planed number of working days for whole activity	Working group		Unit of measurement	Daily efficiency	Total quantum of activity	Needs of working days
				worker	machine				
1.	Land un-rooting	VI-VII	15	1	1	ha	1	100	100
2.	Land clearing	VII	10	1	1	ha	1	100	100
3.	Levelling of ground surface	VIII	12	1	1	ha	2	100	50
4.	Surface planning	VIII	8	1	1	ha	5	100	20
5.	Loading and transport of manure	VI-VII	8	1	1	t	30	3.000	100
6.	Manure spreading	VII	5	1	1	t	30	3.000	100
7.	Loading and transport of mineral fertilizers	VI-VII	4	1	1	t	60	6.000	100
8.	Mineral fertilizers spreading	VII	3	1	1	t	60	6.000	100
9.	Deep ploughing	VIII-IX	15	1	1	ha	1	100	100
10.	Tilling	IX	6	1	1	ha	5	100	20
11.	Harrowing	IX	6	1	1	ha	10	100	10
12.	Surface measuring	IX-X	8	2	-	ha	1	100	100
13.	Marking of plant places	X	6	1	-	ha	1	100	100
14.	Preparation of stakes	VI	10	2	-	piece	25.000	250.000	10
15.	Stakes transportation	IX-X	5	1	1	piece	10.000	250.000	25
16.	Stakes establishment	X	10	2	-	piece	10.000	250.000	25
17.	Plantlets purchasing	VI	1	2	-	piece	250.000	250.000	1
18.	Preparation of plantlets	X	10	2	-	piece	1.000	250.000	250
19.	Plantlets transportation	X-XI	8	2	1	piece	25.000	250.000	10
20.	Holes digging	XI	15	1	-	piece	250	250.000	1.000
21.	Holes disinfection	XI	10	1	-	piece	500	250.000	500
22.	Planting	XI	15	2	-	piece	500	250.000	500

[2] Milić D., Furunđžić, M., Jevđović, M., Kukić, Đ., *Organizacija voćarsko-vinogradarske proizvodnje.* Institut za ekonomiku poljoprivrede i sociologiju sela. Novi Sad, 1993.

The preparation and planting technology, or the plan of working activities, can be graphically presented by the network diagram. A network diagram consists of activities and events. Activity (i-j) is the element in the process which spends time and resources, i.e. labor force, machines, material and others. Thus, in the analyzed model of plantation, under the heading of activities there have been considered working operations, such as: land un-rooting, land clearing, deep ploughing, tilling, harrowing, etc. Activities are graphically presented by a straight line, right oriented by the arrow. Besides the real ones, fictive activities exist too, which show mutual work dependence, but they do not require any time spending, and nor resources. Fictive activities are shown by a dashed line. Activities which connect two critical events, are critical, so they are usually marked by a continuous line. Event or knot (i-j) represents the moment of beginning, or closure, of one or a few activities, and it neither spends any time nor resources. Events are graphically presented by circles, numbered with positive whole numbers. Each chart has a beginning and a closure event, between which activities take place.

Structural Analysis of Network Diagram

After setting up the list of activities shown in Table 1, with a view to network diagram construction, the next step is the determination of mutual logical relations between planned activities, according to the order of their realization. Some activities could start only after the previous ones end, while some of them could be realized at the same time. Considering technological issues and other elements, we should find out which activities have to be performed successively, and which ones can be realized simultaneously. For example, activities numbered 1, 5, 7, 14 and 17 (land un-rooting, loading and transport of manure, loading and transport of mineral fertilizers, preparation of stakes, plantlets purchasing) are not stipulated by previous activities, which means that they have a common starting event. Then, for activity number 2 (land clearing) to begin, activity number 1 (land un-rooting) is necessary. After activity number 2 (land clearing) has ended, activities number 3, 6 and 8 (levelling of ground surface, manure and mineral fertilizers spreading) can start. Moreover, for activity number 6 (manure spreading) to begin, activities number 2, 4 and 5 (land clearing, surface planning, loading and transport of manure) have to be finished. Respecting the basic rules during the construction of the network diagram, the process of drawing the network starts from the beginning event on the left side, ordering the activities in the logical row to the right (Figure 1).

Calculation and Time Analysis According to CPM Method

Each activity (i-j) in the network has the estimated time of duration written above the line of activity (Figure 1), and marked by symbol t_{ij} in Table 2. Activity duration is expressed in days. The shown network has 22 activities and 23 events, from which only one of them is the first, and only one of them represents the final moment of project task realization.

Table 2. List of activities with time of duration, the earliest and latest beginnings and closures, and time reserves

Begin-ning	**Closure**	**Type of activity**	**Dura-tion time**	**The earliest beginning**		**The latest closure**		**Time reserves**		
i	j		t_{ij}	t_i^0	t_j^0	t_i^1	t_j^1	$(S_t)ij$	$(S_s)ij$	$(S_n)ij$
1	2	Preparation of stakes	10	0	10	0	66	56	0	0
1	3	Land un-rooting	15	0	15	0	15	0	0	0
1	4	Plantlets purchasing	1	0	1	0	98	97	0	0
1	6	Loading and transport of manure	8	0	25	0	45	37	17	17
1	7	Loading and transport of mineral fertilizers	4	0	25	0	47	43	21	21
2	14	Stakes transportation	5	10	71	66	81	66	56	0
3	5	Land clearing	10	15	25	15	25	0	0	0
4	20	Preparation of plantlets	10	1	91	98	108	97	80	0

Table 2 (cont.)

5	8	Levelling of ground surface	12	25	37	25	37	0	0	0
6 7	10	Mineral fertilizers spreading	3	25	28	47	50	22	0	0
8	9	Surface planning	8	37	45	37	45	0	0	0
9	11	Manure spreading	5	45	50	45	50	0	0	0
11	12	Deep ploughing	15	50	65	50	65	0	0	0
12	13	Tilling	6	65	71	65	71	0	0	0
13	15	Harrowing	6	71	77	71	77	0	0	0
14	16	Stakes establishment	10	71	81	81	91	10	0	0
15	17	Surface measuring	8	77	85	77	85	0	0	0
17	18	Marking of plant places	6	85	91	85	91	0	0	0
18	19	Holes digging	15	91	106	91	106	0	0	0
19	22	Holes disinfection	10	106	116	106	116	0	0	0
20	21	Plantlets transportation	8	91	99	108	116	17	0	0
22	23	Planting	15	116	131	116	131	0	0	0

Starting from the first event in the network, marked with number 1, it is possible to determine the timing of the earliest possible start of activity. Activities (i-j) can start just after event (i) is done. Those events (i-j) in the network that are connected with event 1 could take place only after the end of all activities which the path with the longest duration consists of. According to that, the earliest ending of the activity (t_j j_o) can be obtained with this formula: $t_j^o = \max\left(t_i^o + t_{ij}\right)$, and that is at the same time with the earliest time of next event accomplishment. In the analyzed model, activities 1-3 (Land un-rooting) last for 15 days, so the next activities 3-5 (Land clearing) could start after this period. At the same time, this is the earliest time of appearance of event 3. The end of events 5-8 (Levelling of ground surface), represents the earliest accomplishment time of event 8. It depends on time duration of previous activities (1-3, 3-5 and 5-8), so the event 8 could be done just after 37 days, which is at the same time the starting time of the next activities 8-9 (Surface planning). For the events which represent the ending of more activities, the earliest accomplishment time is caused by the activity with the longest duration. This is the procedure according to which the earliest accomplishment of all events in network and earliest beginnings of all activities are determined, which are later written in lower left quarter of circle (Figure 1) and given in (Table 2). According to that, the earliest time of accomplishment of closure event 23 is determined by the highest sum of duration time of all previous activities. As it is represented in (Figure 1), that is the period of 131 days, which is at the same time the period of the earliest closure time of the plantation establishment project.

The latest allowed time of event accomplishment is defined as the moment until which all activities that are included in this event should be finished, how definitive time of project realization could be achieved. At the last event, the time of the latest allowed accomplishment is the time spent for its earliest possible accomplishment, while for other events it is calculated by the backward procedure (coming from last to starting event) according to formula: $t_j^1 = \min\left(t_j^1 - t_{ij}\right)$ which is at the same time the latest closure time of previous activity. Accounting backward from 23 event, it is deducted from 131 days the time of activity duration 22-23 (planting) in the sum of 15 days, and the result represents the time limit for the latest accomplishment of event 22, and that is 116 days. Event 19 must start at least in day 106, i.e. after the end of activities 18-19 (holes digging), and it is the beginning of activities 19-22 (disinfection of holes) at the same time. In the same way we determine the latest times of accomplishment for events in which few activities are finished. For example, event 7 should be accomplished no later than day 47, which represents the latest closure of activity 1-7 (Loading and transport of mineral fertilizers) and the earliest start of activity 7-10 (Mineral fertilizers spreading). These amounts are written in the lower quarter of circle Figure 1, and given in Table 2.

Critical Path in Diagram

Critical path in the network connected the beginning and the ending event, and its duration is longer than the duration of any other path between starting and closure knob. This path indicates duration time of whole project and it consists only of critical activities. Under critical activities are considered activities in which in the case of the starting and the ending of events there is not any difference between the moment of the earliest and the latest accomplishment, which means that there are some time reserves.

As it is presented in Figure 1, the critical path consists of activities 1-3, 3-5, 5-8, 8-9, 9-11, 11-12, 12-13, 13-15, 15-17, 17-18, 18-19, 19-22 and 22-23, and those are the following working activities: land un-rooting, land clearing, levelling of ground surface, surface planning, manure spreading, deep ploughing, tilling, harrowing, surface measuring, marking of plant places, holes digging and disinfection and planting.

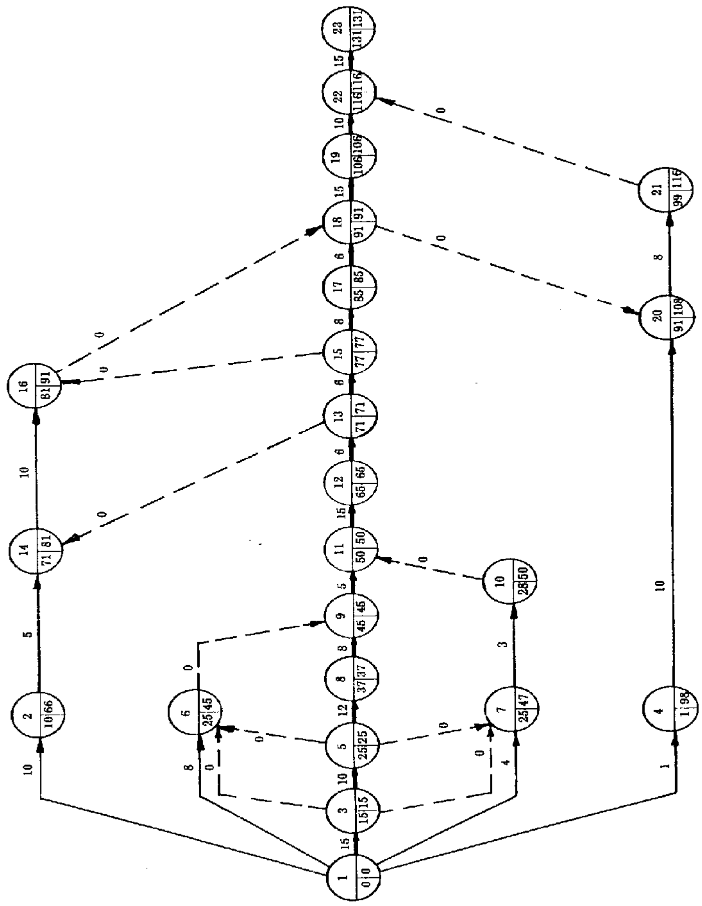

Fig. 1. Network diagram of working operations in process of apple plantation establishment in which is done time calculation and determination of critical path

By adding the time durations of all noticed activities, it is obtained the time period for which the planned project of plantation establishment will be realized, i.e.:

T_p =15+10+12+8+5+15+6+6+8+6+15+10+15 = 131 days

On the network diagram, the sum of 131 days represents a time distance of critical path too. If on this path some it happens for an event to be late, the time period of the whole project would be extended. However, in some cases, the critical path could be shortened, like in the following situations:

1. by excluding some activity, if it is not necessary, or if the risk is not too high, which depends on ground circumstances, physical characteristics of soil, type of rootstock plantation, etc.;
2. by parallel performing of some activities without larger disturbing of logical structure and connection between activities, determined by available machines, labor forces and other means[3].

Time Reserves

If activities have shorter duration time than the maximum allowed, they are considered uncritical. In these cases there is a specific time reserve, which means that the time of their duration can be moved or extended without influencing the end of the whole project. But, changes in their time duration can be done only in the frame of available time reserves. Depending on the observed activity according to the previous and next ones there are: total, free and independent time reserves. *Total time reserve* shows for what time it could be moved accomplishment of some uncritical activity under condition that it has the most suitable position, while previous and next one has the most unsuitable position. According to the formula: $(St)_{ij} = t_j^1 - t_i^o - t_{ij}$ it is determined that total time reserves occurred at activities: 1-2, 1-4, 1-6, 1-7, 2-14, 4-20, 7-10, 14-16 and 20-21. *Free time reserve* represents for what time execution of uncritical activity can be moved considering that the following activities start in their optimal position, and the previous one has finished in the worst position. According to the formula: $(Ss)_{ij} = t_j^o - t_i^o - t_{ij}$ the free time reserves appeared at activities 1-6, 1-7, 2-14 and 4-20. *Independent time reserve* shows for how long execution of one uncritical activity can be delayed, if the former and next ones are in their best position. It is accounted by the formula: $(Sn)_{ij} = t_j^o - t_i^1 - t_{ij}$ and occurred at activities 1-6 and 1-7. Table 2 presents the values of some time reserves.

Conclusion

The critical path with the length of 131 days defines the duration time of the project of plantation establishment realization. The closure event in the chart presents the end of the planting activity. According to that, establishment of apple plantation has to be finished, by calendar, on the beginning of November. All noticed activities have to be started 131 days earlier. In other words, the process of ground preparation should start in the first days of the last decade of June. The presented procedure could be applied on all types of plantations, with a high level of practical assurance.

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Posibilități de raționalizare a amplasării plantațiilor perene

Rezumat

Procesul amplasării plantațiilor perene reprezintă un grup de activități lucrative diverse al căror scop principal este cel de se a realiza într-o perioadă optimă în contextul unor resurse date. Soluția acestei probleme ar putea fi identificată utilizând metoda CPM de planificare a rețelei. Aceasta este una dintre cele mai noi modalități de planificare operativă, care se caracterizează printr-o înaltă flexibilitate, implicând una sau mai multe activități lucrative, într-o singură zi sau într-un sezon. Articolul analizează posibilitățile de conducere rațională a proceselor privind pregătirea terenurilor şi amplasarea plantațiilor, la un cost minim al unor resurse limitate. Procedura metodologică este aplicată pe modelul cultivării merelor.