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ICETsAS 2018 **Journal of Physics: Conference Series** 1376 (2019) 012033 IOP Publishing doi:10.1088/1742-6596/1376/1/012033 1 Development **of Seeding and Planting Scheduling** Algorithms for Contract Farming of Organic Vegetable with Multi Seeding and Planting Center M M Putri¹, Y S Mardhiyyah² and A Rusdiansyah³ ¹Department of Logistics Engineering, Universitas Internasional Semen Indonesia, Gresik 61122, Indonesia ²Department of Agroindustrial Technology, Universitas Internasional Semen Indonesia, Gresik 61122, Indonesia ³Department of Industrial Engineering, Institut Teknologi Sepuluh Nopember, Surabaya 60111, Indonesia E-mail : yunita.mardhiyyah@uisi.ac.id Abstract. Organic vegetables are perishable products with special characteristics because its shelf life is influenced by product characteristics, environmental conditions and production time.

Customer **only buys fresh organic vegetables because its price is more expensive than the non-organic ones.** The scheduling of seeding and planting process becomes the most important thing for organic vegetables producer. They must ensure the right time and good condition in organic vegetables consumer delivery. An organic vegetable products company is implementing a contract farming system. They have some Planting and Seeding Centers (PSCs) across several cities. PSC is an organization which cooperate with farmers in contract farming. The functions of PSC are to seed, distributing the seeding result to farmers, packing vegetables form farmers and shipping vegetables to customers.

Farmers **will plant the seeds received from PSC based on a schedule given by PSC.** This research will develop an algorithm of seeding and planting scheduling by PSC and farmers. There are several types of vegetables: vegetables with seeding, vegetables without seeding, planted inside green house, and planted in an open field. PSC and

farmers are determined by the nearest distance to customers, the availability of green houses and open fields.

The purpose of this algorithm is to optimize PSC seeding and planting scheduling, so we can minimize production costs (seeding, planting, packing and distribution costs) and maximize profits.

1. Introduction The concept of efficiency, optimum and high profit value is important for industry. This is could be obtained by balancing between supply and demand [1], where could be done by proper planning and production scheduling. Indonesia is agricultural country, where agricultural business is still a major business and has a large market share. An increasingly agribusiness sector is organic vegetables.

Vegetables as perishable products or agricultural industrial products are highly specialized product (easily damaged) that characteristics by environmental conditions and timing [2]. ICETsAS 2018 *Journal of Physics: Conference Series* 1376 (2019) 012033 IOP Publishing doi:10.1088/1742-6596/1376/1/012033

2 Other factors that affect the quantity and quality of organic vegetable production are environmental factors such as weather, sunlight and soil conditions [1].

Complexity factor of organic vegetable products need to be controlled to meet the customer needed. This is one of the reasons for the importance of planning and production scheduling of perishable products as well as their distribution to achieve a balance between supply and demand from the agricultural industry. Manufactures of perishable products especially Indonesian organic vegetables apply contract farming concept in producing and distributing vegetables.

The company works together by contracts with the vegetable farmers who will be given seeds based on demand from customers. The company will choose which farmers will plant and when the plantation should be done. The decision of farmers selection and planting time greatly affects the fulfillment of customer demand both quantity and product quality [3]. Farmers will receive revenue from the company according to their harvesting. Vegetables from farmers will be packed and distributed to customers by the company. So that the costs incurred by the company are the costs of the farmer's salary, packing costs and distribution costs [1].

In a greenhouse, farmers can plant two types of vegetables with mixed cropping method [4]. This aims to maximize available land use. To facilitate the process of nursery, packing and distribution then the company made a Planting and Seeding Centers (PSCs) across several cities. The goal is to minimize operating costs and to obtain maximum profit. This research will develop a planning algorithm for PSC seeding and planting

scheduling from a vegetable supplier company. 2. Contract Farming Contract farming is a method to increase production and revenue of farmers (farming, fishery, etc).

Contract farming has been widely carried out in various countries. It is able to prosperify farmers through increased the production [5], increase the market access and prices [6]. This can affect farmers' revenue [5]. Agribusiness partnership is a business strategy that can be carried out by two or more parties within a certain period. This strategy can provide benefits to all parties. This type of partnership is generally in the form of a vertical coordination that is often followed by a contractual relationship or an agreement [7]. There are many planting methods in contract farming.

Mixed cropping and single cropping is two of planting method. Single cropping is planting methods with one type of plant. Mixed cropping is planting methods with various types of plants in an area at the same time. Mixed cropping method mostly used for vegetables with short planting period and once cropping (mustard, spinach, kale, cabbage, etc.). Mixed cropping can increase revenue of farmers [4]. This system was chosen to increase the production with various requests and land efficiency. This research will be compare the efficiency of land with and without mixed cropping method. 3.

Model This research will develop model and algorithm of seeding and planting scheduling to obtain the profit of company. The company produces organic vegetables. They have demand from organic vegetables retails in several cities everyday. Vegetables is perishable product, so they must be delivered to the customer as soon as possible. They have three PSCs to serve all customer in several cities. The customer will be served by the nearest PSC. The PSC is responsible to seed, distributing the seeding result to farmers, packing vegetables form farmers and shipping vegetables to customers. PSC collaborate with farmers by applying a contract farming system.

All farmers plant the seeds according to planting schedule given by the PSC. The illustration of information flow of organic vegetable company can be seen in Figure 1. below. ICETsAS 2018 Journal of Physics: Conference Series 1376 (2019) 012033 IOP Publishing doi:10.1088/1742-6596/1376/1/012033 3 Figure 1. Information Flow Chart of Organic Vegetable Company All vegetables cropped by the farmers will be purchased by the PSC. Every farmer who joins them must meet the company specifications. The company give Green House and open field with same area and quality. All farmers plant some vegetables.

They need different treatment (vegetables with seeding, vegetables without seeding, planted inside green house, and planted in an open field). For seeding, every PSC have

two Green House (GH 1 and GH 2). They use tray for seeding in GH. GH used is determined based on seeding time. Figure 2. Tray for Seeding [8] Each farmer has two GH (GH 3 and GH 4) and open field. Each GH has two blocks (25 m²/block) and each open field has five blocks (25 m²/block). One block for GH or open field only contain not more than two types of plants. If all contract farming farmers' land is full, then the PSC will rent the land and other farmers to avoid backorder or lost sales.

In this research, a linear programming model was refined to schedule seeding and planting time [4] and adjusted to the conditions in the research object. There are several types of vegetables: vegetables with seeding, vegetables without seeding, planted inside green house, and planted in an open field. PSC and farmers are determined by the nearest distance to customers, the availability of green houses and open fields, the productivity and cost aspects.

For scheduling, we use backward scheduling method because the company use make to order system and the vegetables must be delivered as soon as possible. We develop algorithm for seeding and planting scheduling. The algorithm illustrated by Figure 3. ICETsAS 2018 *Journal of Physics: Conference Series* 1376 (2019) 012033 IOP Publishing doi:10.1088/1742-6596/1376/1/012033 4 The Notation: ACGH : available capacity of green house (m²) ACOF : available capacity of open field (m²) F_m : farmer m (m = number of farmer) S_t : the amount of seed for seeding in GH PSC period t P_t : the amount of seed for planting in GH farmer m period t L_{Tj} : lead time or seeding time of vegetable j L_{Pj} : lead time or planting time of vegetable j R_{Vkt} : income earned by PSC k period t M_{Ckt} : maintenance cost of PSC k period t R_{Nkt} : rent cost of PSC k period t B_{Ckt} : backorder cost of PSC k period t L_{Skt} : lost sale cost of PSC k period t t : period i : demand index p : productivity (%) k : PSC index j : vegetable index The constraints: • The amount of seed to be planted: consider the land productivity and demand $???? = ?????? \times (100\% + (100\% \times ??)) (1)$ • The capacity of green house $???? = \times ??^2 (2)$ • The capacity of open field $???? = 5 \times 2 ??^2 (3)$ The objective function: (4) ICETsAS 2018 *Journal of Physics: Conference Series* 1376 (2019) 012033 IOP Publishing doi:10.1088/1742-6596/1376/1/012033 5 Figure 3. Algorithm of Seeding and Planting Scheduling ICETsAS 2018 *Journal of Physics: Conference Series* 1376 (2019) 012033 IOP Publishing doi:10.1088/1742-6596/1376/1/012033 6 4. Numerical Experiment We try with three PSC (GH 1 and GH 2).

Each PSC has four farmers (GH3, GH4). Each farmer plant five vegetable type: mustard caisim, kale, spinach, sweet corn, and chili. Each vegetable has characteristic like in Table 1. Kale and sweet corn do not need seeding process. Chili is not once cropping plant. In one planting of chili, chili can be cropped five times. Table 1. Characteristic of Five Vegetables The data demand in daily, but the seeding and the planting time in weekly.

The farmers can plant every day (can disturb another plant to grow), so we calculate the data demand in weekly. Table 2. illustrates the data demand of PSC 1. Table 2. Weekly Data Demand Table 3.

Seeding Scheduling of PSC 1 ICETsAS 2018 **Journal of Physics: Conference Series** 1376 (2019) 012033 IOP Publishing doi:10.1088/1742-6596/1376/1/012033 7 Table 4. Planting Scheduling of PSC 1 Farmer 1 From data in Table 1. and Table 2., we can simulate our algorithm. The result showed by Table 3. and Table 4. Table 3. illustrates the seeding scheduling of PSC 1. Table 4. illustrates the planting scheduling of PSC 1 Farmer 1. All GH and OF used efficiently. All orders are fulfilled on time and right product. There is not back order and lost sale. So, we can minimize the production cost. 5. Conclusion The PSC has an important role in production and controlling of each farmer.

By conducting a central seeding, farmers are only responsible and focused on planting vegetables. And the company is only focused for seeding, packing and distribute the vegetables. Determining the right amount of planting and planting schedule can control the harvest schedule and the right amount of harvest. We can reduce maintenance cost, rent cost, and lost sales. So, we can produce with minimal production costs. For further research we want to consider the soil treatment process and the variety of vegetables. Soil treatment is needed to maintain the quality of vegetables.

Acknowledgments The authors would like to say thanks to the reviewers for any suggestions to improve the quality of this paper and Community Service of Universitas Internasional Semen Indonesia **for the financial support** of this study. ICETsAS 2018 **Journal of Physics: Conference Series** 1376 (2019) 012033 IOP Publishing doi:10.1088/1742-6596/1376/1/012033 8 References [1] B. N. Tan, European Journal of Operation Research 220, pp. 539-549, 2012. [2] X. L. Wang, Omega: International Journal of Management Science 40(6), pp. 906 - 917, 2012. [3] O. V. Ahumada, Int. J. Production Economics 133, pp. 677-687, 2011. [4] A. A. D. S.

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