纖維 및 에너지生産 增大를 爲한 集約的 林業經營의 必要性*[1]

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The Importance of Intensive Forestry Management for Fiber and Energy Production in Korea*[1]

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增加하는 林產物需要 및 極甚한 에너지 問題로 世界 여러나라에서는 集約的인 林業經營方法으로 單位面積當 生產性을 높이자는데에 많은 관심을 모으고 있다. 이 方法으로 얻은 生產物이 增大될 纖維 및 에너지 需要를 全的으로 充當하지는 못할지라도 적어도 이의 一部를 充當할 수 있을 것으로 보이며 특히 林產物 및 에너지 資源이 不足한 우리나라에서는 集約的인 林業經營이 절대 必要하며 그리고 植栽可能面積, 適切할 樹種 및 既存 林業技術의 利用可能性으로 보아 集約的인 林業經營의 實行可能함을 보인다.

Increased demand for wood products and recent energy crisis have stimulated much attention over the world to the concept of intensive forestry management systems. This shows great potential of increasing biomass yields. Biomass probably will not be a major source to solve the whole problems of fiber and energy shortage but as an alternative source it will, in part, help meet the remarkable demand. In Korea, the systems are not only feasible because of available land areas, many appropriate tree and existing forestry techniques already available, but also urgently needed.

Introduction

World-wide demand for wood and wood products is expected to increase dramatically to the year 2000 (USDA Forest Service, 1973). Also, its anticipated Korea demand will exceed 40 million m^3 in the year 2010 (Park *et al*, 1978). However, sizable areas of forest lands have been continuously lost due to suburban development, highways, recreation and non-timber uses. Therefore, one of the problems confronting the forest science is how to produce larger quantity of fiber in a short period.

Another problem threatening the science and technology over the world is to substitute for fossil fuels because of rapid resource depletion to extensive uses. Energy consumption in the United States is projected to triple by the year 2000 (Grantham and Ellis, 1974).

Since 1973 the continued rise in prices of petroleum, natural gas and coal evoked many energy researches to search for alternative energy sources. The renewable resources such as hardwood and softwood forests, minor forest products, agricultural crops and residues, and livestock offer the potentialities for supplemental energy sources (Bethel and Schreuder, 1976; Atchison, 1976).

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Innovative modes of intensive culture with woody plants show great potentials of producing exceptionally high yields of biomass per hectare in a small land basis for use as both fiber and fuel (Gordon, 1975; Schreiner, 1970; Szego and Kemp, 1973). Therefore, this paper was to discuss the importance of biomass yield increase via intensive culture systems for use as both fiber and alternative energy source in Korea.

Intensive silviculture for maximum fiber production

Since 1966 the concept of intensive culture has received much attention in the United States as a means of attaining high biomass yields. This involves such several management practices as the fertilization, irrigation of closely spaced, rapidly growing species (cottonwood, hybrid poplars, sycamore) for coppice rotations of 3 to 7 years (McAlpine *et al*, 1966; Schreiner, 1970). In addition, pest and weed control, site fertility and appropriate length of rotation should be considered to successfully accomplish the system (Figure 1) (Heiligmann, 1975; Lee 1978; Myers *et al*, 1976)

Biomass yield varies with species or clones. Intensively managed *Populus* hybrids in Ontario produced 5 to 19 tons/ha/year of stem-branches dry weight from a 2-year coppiced plantation (Anderson and Zsuffa, 1975). In Wisconsin 3-to 4-year-old *Populus* 'Tristis #1' yielder 6 to 13.5 tons/ha/year of stem-branches dry weight (Dawson *et al*, 1976). Stem-branches dry weights of intensively cultured hybrid poplar clones ranged from 2.4 to 4.1 tons/ha/year before coppicing while from 4.1 to 5.8 tons/ha/year after coppicing in Iowa and Wisconsin (Lee, 1978). In Georgia 4-year-old *Platanus* produced 9.4 tons/ha/year of bole-branch dry weight (Saucier *et al*, 1972). Sixteen tons/ha/year of bole-branch dry weight were yielded by the 4-year-old *alnus* in British Columbia (Smith and DeBell, 1974).

From the above results there are strong indications that large increase in biomass yield is possible and woody plants under this system have some potential advantages in dry-matter productivity over annual crop plants (Gordon, 1975). Under intensive management the potential growth per hectare per year would increase by 12 percent in the United States (Spurr and Vaux, 1976). In particular, planting of genetically faster-growing trees or a tree ideotype indicated by Dickmann (1975) will increase fibers to satisfy the predicted doubling in wood products demand.

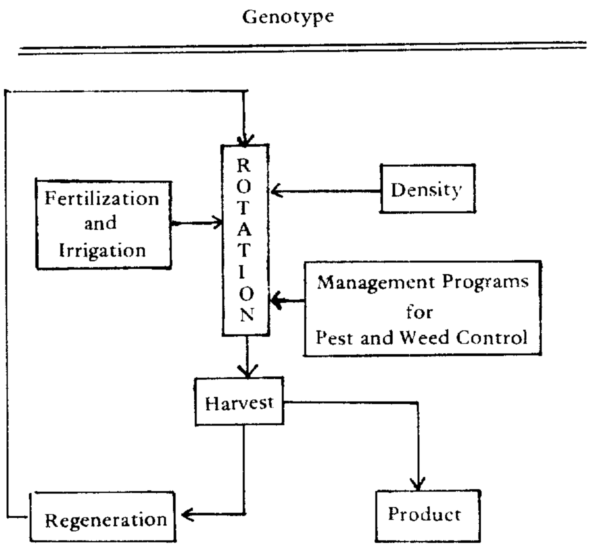

Fig. 1. Intensive Culture systems.

Spacing easily manipulated is the most powerful tool to control tree form and wood quality (Larson, 1962), which is true of short-rotation intensively cultured plantations. Up to fourth year, biomass yield of bole-branch of sycamore increased with increasing planting density (Saucier *et al*, 1972; Kennedy, 1975). Dry weight yields of 3-year-old *Populus* grown in irrigated and fertilized plots were the highest at the most dense plot whereas those were the lowest at the least dense plot (Dawson *et al*, 1976). However, that of 6-year-old black cottonwood was not similar to this trend (DeBell, 1975). Even is close spacings are better for the maximum utilization of the site and for biomass yield, they exhibit more severe competition for water or nutrients by roots and for light as well as more expensive costs for planting, management and harvesting.

Length of rotation is a limiting factor to coppice-rotation systems because of its effects on regeneration capabilities. The cutting cycles greater than 2 years showed higher biomass yields of sycamore than a 1-year cycle (Kormanik *et al*, 1973). The coppice growth of black cottonwood with a 4-year cutting cycle was better than that with 2-year (DeBell, 9175). Therefore, first coppice may be best when root systems are well developed, at least 3 or 4 years after planting. Considering narrow planting spaces, very short rotations such as 2 to 5 years seem to provide the best conditions for maximum biomass yields of *Populus* clones.

Energy plantations

Solar energy is a very promising source of energy for the future. It is ample and can be converted by green plants into stored organic matter which could be used for various kinds of fuels. The concept of establishing 'energy plantations' has recently been advanced (Szego and Kemp, 1973; Grantham and Ellis, 1974). This has received much criticism such that plantations are not economically feasible much criticism such that plantations are not economically feasible and also require large land areas. However, the long term advantages are very considerable in the following respects (Hall, 1979); (1) every year biomass energy is being stored about ten times the world's annual use of energy, (2) biomass products are renewable, dependent on technology already available with minimum capital imput, can be developed with present man-power, and (3) ecologically inoffensive and safe. In addition, solar energy product requires less energy than other non-renewable resources for its processing (Cliff, 1973). For example, the electrical energy required to produce 1 ton of lumber is 453 kwh, which may be compared with 3,780 kwh for 1 ton of steel and 20,160kwh for 1 ton of aluminum.

Furthermore, wood has still mostly being used as fuels in the world. Wood fuel is about one-sixth of the world annual fuel supplies and approximately half of all the trees harvested is used for cooking and heating. In non-OPEC countries (40% of the world's population),wood, dung and agricultural waste are used up to 90% of their total energy use.

There are many studies on the biomass uses for energy. In the United States, fuels from biomass may possibly supply 10% or more of a curtailed energy consumption. In Canada, large amount of methanol production from biomass could provide between 4 and 42% of the transport fuels by 2025. Furthermore, Raitanen (1978) estimated that to produce 100 million gallons of methanol annually from hybrid poplar biomass a 75,000 hectare plantation area would be required for stands with 35,864 trees/ha, a 135,000 hectare area for stands with 4,303 trees/ha or a 17,000 hectare area for stands with 1,077 trees/ha. In the Philippines, 1 9,100 hectare fuel wood plantation would supply the needs of a 75 MW steam power station if it were not more than 50 km distant.

Recent studies of Zavitkovski (1979) that 10-year-old *Populus* 'Tristis #1' and jack pine grown under intensive culture produced 166 and 119 mt/ha total dry weight. If this figure is converted into energy unit, almost 2,400 and 1,900 MB tu/ha10-year roration would be available from *P.* 'Tristis #1' and jack pine plantations. This is equivalent to 430 and 340 barrels of oil, respectively.

Are intensive culture systems feasible in korea?

Korea demand for wood products is projectd to be 12 million m^3 by the year 1980 and 40 million m^3 by the year 2010 (Park *et al*, 1978), which are more twice and seven times than that in the year 1972. On the other hand, energy consumption in Korea in 1981 is expected to double that in the year 1972 (ROK Ministry of Science and Technology, 1977).

Today, fuelwood forests had been already established according to Korean Forestry Statistics(1978). Because wood is being used by 35% of total households for cooking and heating, and fossil fuels are mostly importing except for coals, we are sure that the use of biomass for energy will be helpful for reducing the consumption of fossil fuels. Therefore, we believe that intensive culture systems are necessary and feasible for increasing fiber and energy production in Korea in the following points; (1) potentially usable land areas, forest land areas consist of 67% of the total land areas, (2) good native tree species and improved, fast-growing species available, and (3) existing forestry techniques already available.

Candidate species for intensive culture systems are as follows:

Hardwoods

Populus alba x *glandulosa*
Populus nigra x *maximowiczii*
Populus x *euramericana*
Populus deltoides
Quercus spp.
Robinia pseudoacacia
Alnus spp.
Salix spp.
Acer negundo
Platanus spp.

Conifers

Pinus rigida
Pinus rigidataeda
Pinus thunbergii
Larix leptolepis

Shrubs

Lespedeza spp.
Amorpha fruticosa

At 500 to 700 trees per hectare plots, a 6-year-old *Populus alba* x *glandulosa* produced 4.8 tons/ha/year of dry weight and 10 tons/ha/year were yielded at a 9-year-old plots (Kim *et al*, 1977). *Lespedeza* produced about 4.3 tons/ha/year of dry weight at the $2^m \times 1^m$ spacing on the hillside (J.H. Kim, 1978, Unpublished Research Report of the Institute of Forest Genetics).

Location of intensive culture plots is also an important factor for the product utilization. The nearer plots are established to the mill, the more easily products are transported and utilized. In Korea, side areas of road, railroad and highways, and those near households would be recommended for the establishment of intensive culture plots.

Conclusions

Although biomass may not be a major source of energy for commercial power production or for chemical feedblck, it will help meet large demand for wood prodicts and energy. Intensive culture with woody plants is not only necessary for all the countries over the world, but the systems for both fiber and energy production are urgently needed and feasible in Korea, because we have potential land areas available and good improved tree species available.

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