THE PROSPECT OF GROWING SOBA (BUCKWHEAT) AS FLOUR PRODUCING PLANT IN INDONESIA FROM AGRO-METEOROLOGICAL POINT OF VIEW

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ABSTRACT

Soba plants (buckwheat) are relatively new in Indonesia, because originally it admitted as subtropical crops. Soba as flour producing plants enjoy the nutritional and health benefit food and it can be used in variety of food such as noodles and pancake. Air temperature and solar radiation are important agro-meteorological factors that correlated to varieties, sowing dates and planting areas. Preliminary experiment indicated that soba plants can be planted also in tropical regions at high altitude regions, but still need more detail information from agro-meteorological point of view.

An attempt has been done to study the influence of different temperature regimes on dry matter production and yield of soba plant (buckwheat – Fagopyrum esculentum Moench*) in Indonesia. Two sites of West Java have been chosen, viz Segunung (S_1) and Ciawi (S_2) which are located at 1150 m and 400 m above sea level, respectively. A cultivar of Kitawasesoba was grown at three population densities and three sequential times. Dry matter productions were observed weekly and yields were sampled at harvesting.*

The results of present experiments showed that dry matter production and yield of soba were great influenced by different temperature regime. The results indicated that the cooler the site was, the higher the dry matter production and yield per unit of land. The average dry matter production of S_2 has depressed about 42.89% from that of S_1, namely 531.57 g m^{-2} and 930.43 g m^{-2} for S_2 and S_1, respectively. Whilst, the average yield per hectare of S_2 was decreased about 48.54% from that of S_1, those were 1.466 ton ha^{-1} of S_2 and 2.849 ton ha^{-1} of S_1. Those values, however, are much higher than the world average yield of soba, namely 0.898 ton ha^{-1}.

Based on the experiments, the prospect of growing soba in tropical regions is promising to support food sufficiency and ecological farming , because of their growth is very short, easy to manage with low input of water, fertilizer and pesticide, even it can be planted through the year in suitable places.

Introduction

Soba plants (Buckwheat) are relatively new in Indonesia, because originally it admitted as subtropical crops, which occur in temperate region of Euro-Asia. Soba is belongs to the family Polygonaceae, genus *Fagopyrum* Meisn. In general, there are three kind of soba plants, viz common buckwheat (*Fagopyrum esculentum)*, tartari buckweat (*F. tartaricum)*, and cymosum buckwheat (*F. cymosum),* (Wei, 1995). Commonly soba plant can be planted as green manure plant, nectar source for honeybees or planted for flour consumption. The growths of soba plant are highly correlated to air temperature that determines variety of dry matter production and yield.

Soba plants are grouped as neutral or short day plants, and determined as pseudo-cereal. Air temperature and solar radiation are important ecological factors correlated with varieties, sowing dates and planting areas. Growths and developments of soba plants are highly influenced by air temperature of sites (Chai Yan *et al*., 1995), and air temperature is also determine growth characteristics of cultivar and yield (Feng Shanhai, 1995). Optimum temperature for blooming period is 10^0C, between blooming and ripening period is 18-19^0C (Gorski, 1986). In term of plant-water relationship, Sugimoto and Satou (1995) showed that soba plants were tolerant to excessive soil moisture condition, but it susceptible to flooding.

Russian is a country that soba area cultivated in the largest of area, China comes in second then Brazil, Poland, USA, Japan and Kazakhstan (FAO, 1999). In those countries, soba plays an important role in crop rationalization for ecological farming (Wei, 1995). The soba exporting countries among others are China, USA, Canada, Russia and Brazil, while the most importing country is Japan which import at almost 80% of its yearly demand. According to FAO (1999), the average yield of soba of the world has attained 0.898 ton ha^{-1} with arrange from 0.459 ton ha^{-1} of Russia to 2.568 ton ha^{-1} of France.

Based on preliminary experiments those have been done earlier at Segunung of West Java (1150 m above sea level), soba plants indicated can be planted also in tropical regions, at high altitude places. Their growths are very short, easy to manage with low input of water, fertilizer and pesticide. Therefore, in Indonesia where has many mountainous area, could be considered to grow soba plants as complementary and an alternative crop to be developed as flour-producing plants.

Soba enjoys the nutritional and health benefits as nutraceutical food and it can be used in variety of food matter such noodles, pancake, bread, etc (Udesky, 1992 in Edwardson, 1996). The result of analysis that have been conducted at Laboratory of Food Management, Bogor Agricultural University (2001) showed that soba seeds contain of : 14.4% protein, 71.4% carbohydrate, 1.4% fat and 4.9% fiber. Additionally, according to Udesky (1992) and Thacker *et al.* (1984 *in* Edwardson, 1996) soba contain vitamin P, B1 and B2 and has an excellent amino acid composition, each are : arginine 0.9%, histidine 0.33%, isoleucine 0.46%, leucine 0.84%, lycine 0.77%, methionine 0.19%, phenylalanine 0.56%, thereonine 0.49%, and valine 0.60%.

The purpose of recently experiments were to study the influence of different temperature regime which were characterized by altitude difference of sites, on dry matter production and yield of soba plants in tropical regions of Indonesia. The general objective of this experiment is to evaluate the prospect of growing soba as flour producing plant in Indonesia.

Methodology

The experiments have been conducted at two site of West Java to get significant difference of environmental temperature. First site of S_1 was located at 1150 m above sea level with soil type of sandy-loam in experimental yard of " Balai Penelitian Tanaman Hias Segunung", Pacet Subdisdtrict, Cianjur District. Secondly, site of S_2 that was placed at 400 m above sea level with soil type of clay –loam in experimental yard of "Balai Penataran dan Pelatihan Pertanian", Ciawi Subdistrict, Bogor District. Sowing dates in both sites were treated into three sequential time, namely T_1 on April 27^{th} , T_2 on May 27^{th}, and T_3 on June 28^{th} 2000 to see the effect of different sowing dates on yield and to get the best time for sowing dates. The plants were grown at three population densities to see the effect of different population densities in resources utilization among plants, viz P_1, P_2, P_3 of 200, 160 and 133 plants m^{-2}, respectively. Fertilizer that used consists of 3 ton organic manure ha^{-1}, 40 kg N ha^{-1}, 15 kg P_2O_5 ha^{-1}, and 30 kg KCl ha^{-1}. Cultivar of soba plants that used was *Kitawase* (*Fagopyrum esculentum* Moench, cv. *Kitawasesoba*).

Climatic data was taken from climatic station of *Inlitbio – Pacet* (Segunung) and climatic station of *Balai Penelitian Ternak* (Ciawi). Dry matters productions were observed weekly starting at two weeks after sowing until sixth week and yield were sampled at harvesting. Harvesting was done when 75% seed of populations have brown color (Edwardson, 1995).

Results and Discussion

Effect of different temperature regime

Difference in elevation caused air temperature difference of sites. Based on adiabatic process, the higher the place above sea level was the cooler the air temperature. Climatic parameters along research period are shown at Table 1.

As consequences of temperature difference between S_1 and S_2, plant growth of S_1 showed longer than of S_2. Furthermore, harvest period of S_1 was took about 55 days, while that of S_2 was only about 45 days, and it means around 10 days faster. Although, the soba plants typically matures in 75 to 95 days (Edwardson, 1996), but because of cultivar that used in these experiments is early maturing type, this might contribute to their reduced harvest period. The results need to be clarified using more than one variety to get consistent pattern of harvest time.

Table 1. Climatic parameters of sites along research period

Sites	Air Temperature			Rainfall	Daily Wind Velocity	Daily Radiation
	Max	Min	Avg.	(mm)	(m s^{-1})	(cal cm^{-2})
S_1 (Segunung)	25.0	16.6	20.5	254.0	3.99	300.7
S_2 (Ciawi)	27.2	20.3	23.7	114.4	2.57	430.9

Table 2 shows that dry matter production, yield components, and yield of S_1 were greater than and significant difference to those of S_2. The cooler the site temperature regime was, the higher the dry matter production and yield per unit of land. Dry matters per m^2, number seeds per plant, 1000 seeds weight, and seeds yield per ha of S_2 decreased about 42.89%, 44.14%, 8.91% and 48.54% from those of S_1, respectively. The possible reason for decreasing in seeds yield as affected by different temperature regime were generated by shortage of the number of the seeds per plant rather than 1000 seed weight difference. The seeds yield produced in these experiments, however, were much higher than the world average yield, namely 0.898 ton ha^{-1} (FAO, 1999).

Table 2. Average dry matter production, yield components, and yield of soba plant as affected by different temperature regime

Sites	Dry matter (g $plant^{-1}$)	Dry matter (g m^{-2})	Numbers seed ($plant^{-1}$)	1000 seeds weight (g)	Seeds weight $plant^{-1}$ (g)	Seeds weight m^{-2} (g)	Seeds yield (ton ha^{-1})
S_1	5.772a	930.755b	61,076a	28.8889a	1.770a	284.919a	2.849a
S_2	3.253b	531.573b	34,115b	26.3148b	0.897b	146.551b	1.466b

Note: Numbers followed by same letter at same column are not significant difference using Duncan double distance test at 0.05 level.

Effect of sequential of sowing dates

The results of dry matters production and yield of soba plants as affected by sequential of sowing dates could be shown in Table 3. The highest dry matter production was attained at site of S_1 on second sowing of T_2, this value was not difference with T_3 but significant difference to T_1. It caused that during second sowing of T_2, rainfall more spread along plants growth period, while during T_1 high rainfall and wind velocity at fifth week caused plants fall down. It is low rainfall, however, during T_3.

The highest dry matter production of S_2 was attained on T_3 about 612.304 g m^{-2}, but Duncan test shows is not differ significantly to T_1 and T_2. This condition was possibly caused by rain which fall on few days before harvest (days 43-45th), makes soba plants generated new buds and leaves, subsequently increasing plants dry weight.

The highest seed productivity of S_1 was reached about 3.084 ton ha^{-1} on T_2, but this yield was not differ markedly to T_1 and T_3. In contrast, the highest seed productivity of S_2 was attained on T_1 about 1.661 ton ha^{-1} and this value was not differ to T_2, but was significant difference to T_3. The results indicated that the yield of soba per land area were not influenced markedly by sowing dates, especially at site of S_1 which has climatic condition that suitable for growth. Lower yield of S_2 on T_3, however, was most probably due to rain that fall too late after seed filling and nearly to harvest period (43-45th days after sowing) (Koesmaryono *et al*., 2001). In general, the effect of different sowing dates occurred on yield were varied depends on weather during growth period, mostly related to soil water availability from rainfall. According to Edwardson (1996), soba plant is quite sensitive to periods of drought stress.

Table 3. Climatic condition of site, dry matter production and yield of soba plant as affected by sequential of sowing dates.

Sowing dates (T)	Air temperature (°C)			Rainfall (mm)	Total radiation (cal cm^{-2})	Daily wind velocity (m s^{-1})	Dry matter (g m^{-2})	Seeds yield (ton ha^{-1})
	Max	Min	Avg					
S_1T_1	25.2	17.4	20.9	381	15612	5.644	643.665b	2.724a
S_1T_2	24.8	16.7	20.3	245	15904	3.248	1175.107a	3.084a
S_1T_3	24.9	15.8	20.3	136	18407	3.086	973.492a	2.739a
S_2T_1	27.5	20.4	23.9	110	18382	2.643	479.398c	1.661b
S_2T_2	27.1	20.3	23.7	100	19286	2.486	503.018c	1.468b
S_2T_3	27.1	20.2	23.6	134	20043	2.586	612.304c	1.268c

Note : Numbers followed by same letter at same column are not significant difference using Duncan double distance test at 0.05 level.

Effect of plant population density

The effect of different population densities on soba plants could be seen in Table 4. The results of present experiment were consistent to other plants like on soybean (Koesmaryono *et al*., 1997a). The higher the population was the higher the dry matter production per unit area, but the lower of it per plant. Numbers of seed per plant were also decreased with increasing plant populations. Although weight of 1000 seeds were not differ markedly among population, but due to shortage number of seeds per plant with increasing population and hence the yield were varied accordingly.

Table 4. Average of dry matter production, yield components, and yield of soba as affected by different population densities.

Population (P)	Dry matter (g plant^{-1})	Dry matter (g m^{-2})	Number of seed (plant^{-1})	1000 seeds weight (g)	Seeds yield (ton ha^{-1})
S1P1	4.981b	996.244a	51.114b	28.344a	2.898a
S1P2	5.709b	913.611b	64.917a	29.311a	3.050a
S1P3	6.627a	881.408b	67.198a	29.011a	2.599b
S2P1	2.958c	591.797b	32.830c	26.211b	1.721c
S2P2	3.649c	583.911b	34.323c	26.189b	1.436d
S2P3	3.151c	419.012c	35.193c	26.544b	1.239d

Note : Numbers followed by same letter at same column are not significant difference using Duncan double distance test at 0.05 level.

Increasing population has caused competition in resources utilization among plants, particularly for radiation and in most instances lower part of canopy will be shaded. As consequences, leaves at lower part of canopy have lower photosynthetic rate due to lack of radiation (Koesmaryono *et al*., 1997b; Koesmaryono *et al*., 1998). This situation often causes fewer yield. The results showed that population P_2 (160 plants m^{-2}) assumes to be an optimum population for soba plants grown at high altitude such as S_1. In this case, the possible reason is that the densely populated of P_1 at S_1 performed vigorous plants which then caused increasing competition within population and hence decreasing the yield of P_1. At site of S_2, however, a dense population of P_1 gave the highest yield, and there is a trend that closer population even more than 200 plants m^{-2}, will increase plants yield. The phenomena most probably related to climatic condition of S_2, especially air temperature that was quite high, which caused soba plants grew and developed under it is genetic potency. In fact, plants grew relatively stunt and reached lesser yield; even though harvest periods were faster. Because of stunt growth, dense population did not have significant competition among plants, therefore leaves at lower part of canopy also did not have significant shaded.

Thermal Unit at different temperature regime

The result of the experiment indicated that the thermal unit of soba plants was not influenced markedly by altitude and sowing dates. The thermal unit needed for each stages of soba plants development as follow; planting to emergence period was 76.7 ^{o}day, bud flowering was 264.3 ^{o}day, flowering was 434.8 ^{o}day, first green seeds was 513.3 ^{o}day, and for the whole growth and development period was 848.7 ^{o}day.

Table 5. Growing degree days at each growth periods of soba plant at different locations and sowing dates

Location	Sowing date	Emergence period	Bud Flowering	Flowering	First green seeds	Harvest Period
		(^{o} day)	(^{o} day)	(^{o} day)	(^{o} day)	(^{o} day)
S_1	T_1	78	270	451	531	875
	T_2	80	267	431	502	842
	T_3	74	257	426	502	826
Average		77.33	264.67	436	511.67	847.67
S_2	T_1	78	267	437	513	851
	T_2	75	263	432	524	842
	T_3	75	262	432	508	856
Average		76	264	433.67	515	849.67
Total Average		76.67	264.33	434.83	513.33	848.67

Cha *et al.* (1989) reported that soba plants need 480 – 630^{o}day for the whole growth and development period, while Feng Shanhai *et al.* (1995) found that tetraploid and diploid plants need 1640 – 2679 ^{o}day and 1231 – 2472 ^{o}day , respectively. The difference of thermal unit in this case maybe correlated to cultivar of soba plants and climatic environment that influenced physiology of the plants.

Conclusion

Based on the experiments, the prospect of growing soba in tropical regions is promising to support food sufficiency and ecological farming , because of their growth is very short, easy to manage with low input of water, fertilizer and pesticide, even it can be planted through the year in suitable places.

The results of present experiment showed that dry matters production and yield of soba were great influence by different temperature regime. Soba plants that planted at 1150 m above sea level (S_1) with cooler of air temperature had harvest period about 55 days than it planted at 400 m above sea level (S_2) there was only 45 days, that the means 10 days faster. The thermal unit of soba plants was not influenced markedly by altitude and sowing dates. The unit amount for the whole growth and development period was 848.7 ^{o}day.

The experiments also revealed that the cooler the site temperature was, the higher the dry matter production an yield of soba per unit area. The average dry matter production of S_2 has depressed about 42.89% from that of S_1, namely 531.59 g m^{-2} and 930.45 g m^{-2} for S_2 and S_1

respectively. Furthermore, the average yield of soba per unit area of S_2 was decreased about 45.54% for that of S_1; those were 1.466 ton ha^{-1} of S_2 and 2.849 ton ha^{-1} of S_1. Those values of yield, however, are much greater than the world average, namely 0.898 ton ha^{-1}.

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