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A STUDY OF OPTIMUM CROPPING PATTERN AND IRRIGATION SYSTEM ON COTTON + SOYBEAN CROPPING AT LOWLAND OF RAINFED AREA, SOUTH SULAWESI

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ABSTRACT

The study was conducted in Takalar, South Sulawesi from February to March 1992 and from April to September 1994. The first study was conducted through survey method with linear programming models as the tool for analysis. Based on the results of the first survey, the second study was arranged in a randomized block design, consisted of three levels of cotton row, three levels of soybean row, and three levels of irrigation systems. From the first study, it was revealed that in an optimum condition, the cropping pattern for rice field was rice (cotton + soybean) with a farm size of 0.95 ha respectively. Labour was the constraint in January, February, April, June, and December. Within those months the farmer families were not sufficient to manage the farms, so that the farmer needed to hire labours. On the contrary, in March, July, August, September, October and November, there were excessive family labours. Surface water was also a constraint in the irrigation of cotton + soybean on rice field, in June, July and August, so that needed additional ground water supply. The growth of stems, leaves and roots in one row cotton was higher than two or three rows. But the treatment with one row cotton was higher in shedding because it did not supported with good irrigation system. The highest yield (1,881 kg/ha cotton seed + 715 kg soybean/ha) was produced in three rows of cotton and seven rows of soybean that was irrigated at 0-60 days after planting at 50 % field capacity and at 61-120 days after planting to make 100 % field capacity. The profit of the farmers could be increased up to Rp. 828 333/ha/year under optimum condition.

Key words : Cropping pattern, irrigation system, *Gossypium hirsutum, Glycine soya*

RINGKASAN

Kajian pola bertanam dan sistem pengairan yang optimal bagi usahatani kapas + kedelai di lahan sawah tanah hujan, Sulawesi Selatan

Penelitian dilaksanakan di kabupaten Takalar, Sulawesi dari bulan Pebruari sampai Maret 1992 dan bulan April sampai September 1994. Penelitian pertama dilakukan dengan metode survei yang di analisis dengan program linier. Penelitian kedua dirancang berdasar hasil temuan penelitian pertama dan disusun dengan rancangan acak kelompok. Perlakuan terdiri tiga macam jumlah barisan kapas, tiga macam jumlah barisan kedelai, dan tiga macam sistem pengairan. Hasil penelitian pertama menunjukkan bahwa pada kondisi optimal pola tanam untuk lahan sawah adalah padi-(kapas + kedelai) dengan luas masing-masing 0.95 ha. Tenaga kerja merupakan kendala pada bulan Januari, Pebruari, April, Juni dan Desember, artinya pada bulan-bulan tersebut tenaga kerja keluarga tidak cukup untuk mengelola usahatani sehingga perlu menyewa tenaga kerja dari luar keluarga. Sebaliknya pada bulan Maret, Juli, Agustus, September, Oktober, November terjadi kelebihan tenaga kerja keluarga. Air merupakan kendala pada bulan Juni, Juli dan Agustus untuk tanaman kapas + kedelai di lahan sawah sehingga perlu ada tambahan air dengan menggunakan air tanah. Pertumbuhan batang, daun, dan akar menurut hasil pengamatan pada penelitian kedua lebih tinggi pada perlakuan satu baris kapas dibandingkan dengan perlakuan dua baris kapas dan tiga baris kapas. Namun jumlah keguguran lebih banyak pada perlakuan satu baris kapas karena tidak didukung oleh sistem pengairan yang baik. Produksi tertinggi, yaitu 1 881 kg/ha kapas berbiji dan 715 kg/ha kedelai dihasilkan dari perlakuan tiga baris kapas dengan tujuh baris kedelai yang diairi dengan sistem pengairan setara dengan 50% kapasitas lapang pada umur 0-60 hari disusul dengan 100% kapasitas lapang pada umur 61-120 hari. Keuntungan optimum petani meningkat Rp. 828 333/ha/tahun.

Kata kunci : Pola tanam, sistem pengairan, *Gossypium hirsutum, Glycine soya*

INTRODUCTION

Cotton (*Gossypium hirsutum L.*) is the main raw material for textile industry and textile products. According to WORSHAM (1989), 90% of world requirement is obtained from cotton fiber and the rest (10%) from synthetic fibers. In Indonesia cotton demand increases every year proportionally to the demand of textile and textile products.

Data from the Directorate General for Estate, Crops, Indonesian Textile Association and Ministry of Industry (1984-1993) showed that domestic demand of cotton increased 16.1 % per year. In 1993 the demand was 451 620 tons equal to US $ 0-80 billion.

Indonesian export of textile and textile products increased 9.4 % per year equal to US $ 2.73. billion. In 1993 this export occupied second position of non oil and gas foreign exchange earnings after plywood. Domestic production of cotton in that year reached only 30 325 tons equal to 6.1 % of all fiber needed for the textile industry, and the rest 93.9 % had to be imported from the United States, China, Pakistan and South America.

In Indonesia, the productivity of cotton farmed on dryland is between 500 and 750 kg per ha. The research results of the Research Institute for Tobacco and Fiber Crops showed that the productivity could be increased to 1.5-2.0 tons per ha, even it was not difficult to achieve 2.5 tons per ha, if it was managed with technical irrigation (HASNAM *et al.*, 1989). This low productivity was caused by: (1) most of the cotton areas (60%) in South Sulawesi, East Nusa Tenggara and West Nusa Tenggara are on marginal land and dry climate with 500 mm rainfall intensity for four months, (2) the main pest *Helicoverpa armigera* severely attacks the plantation on dryland (FACHRUDDIN, 1990).

For those reasons, an effort to increase cotton production could be made through extensification at lowland. It was estimated that about 137 839 ha under utilized lowland in South Sulawesi can be planted with cotton (BASIR, 1990).

This research was conducted to determine an optimum cropping pattern and irrigation systems for farming cotton + soybean at the lowland of rainfed areas.

MATERIALS AND METHOD

The research was conducted at the lowland of rainfed area in Takalar, South Sulawesi. The altitude is 15 m a.s.l. with alluvial soil. The research was divided into two steps.

Survey method was used as the first step from February to April 1993 through interviewing 40 farmers selected by random. Data were analyzed by simplex algorithm method (LP 88 Programme) to select the combination of several production activities which could maximize farmers income. Experimental design used in the second step was a randomized block, where the treatments arranged factorially in three replications.

The factors tested were (1) number of cotton plant rows at three levels: one row (C_1), two rows (C_2) and three rows (C_3), (2) number of soybean rows at three levels: five rows (S_1), seven rows (S_2) and nine rows (S_3) and (3) irrigation systems at three levels i.e W_1 = 50% field capacity (0-60 dap) and i.e W_1 = 50% of field capacity (61-120 dap), W_2 = 50 % of field capacity (0-60 dap) and 75 % of field capacity (61-120 dap), W_3 = 50 % of field capacity (0-60 dap) and 100 % of field capacity (61-120 dap).

Cotton of Kanesia-2 variety was planted on mounds and soybean of Willis variety was planted on furrows according to treatment combinations. Cotton was planted one week earlier than soybean. Cotton plant-spacing was 80 cm x 25 cm and soybean 25 cm x 25 cm. Irrigation water came from a weld of 7 m depth, dug and pumped with a 2 inches pump-machine. The plots were watered until field capacity was fulfilled.

Ten samples plants were selected by random from each plot. Growth and yield components were measured. Plant parts i.e. roots, stems, leaves and generative parts were observed by drying them. Yield of cotton fiber and soybean

seeds were measured for each plot. The quality of fiber was analyzed in the laboratory of The Research Institute for Tobacco and Fiber Crops, including fiber length, strength and smoothness. Economical analysis was used for number of labours per plot, seeds, fertilizers, insecticides, water volume per plot, input and output values.

RESULTS AND DISCUSSION

The first study

Optimum cropping pattern at lowland was rice 1 - (cotton + soybean), from an area of 0.95 ha. Cropping pattern of rice 1 - rice 2 was not included in optimum design and rice 2 caused financial loss about Rp 89 500 per ha per year.

Family labours were in over supply in March, August, September, October and November for about 4.6, 44.6, 40.3, 60 and 60 mandays. They worked off-farm to get additional income. On the other hand, in January, Februari, April, June and December, there was a lack of family labours about 34, 8.3, 18.6, 6.2 and 9.9 mandays. So the farmers needed to hire the labour and of their.

In the optimum condition, water requirement for cotton + soybean in April and May was fulfilled by rainfall, whereas in June, July, August and September the lack of water was about 12.70, 184.18, 174.10 and 99.82 mm.

The second study

Vegetative and generative growth

The effect of number of cotton rows, number of soybean rows and irrigation systems on vegetative and generative growth of cotton at 110 dap is presented in Table 1.

The height of plant at pattern C_3 (3 rows) was 109.9 cm, higher than that at pattern C2 (2 rows) and C1 (1 rows), and there was no significant difference between C_1 and C_2. Lateral growth of cotton at pattern C_3 in each row was inhibited by other rows and this stimulated vertical growth dominantly which finally affected plant height. HASNAM and SULISTYOWATI (1989) showed that plant height of Reba BTK 12, Tamcot SP-37 and KI 128 planted in monoculture was more than cotton in intercropping pattern.

There were significant differences among irrigation systems in each cropping pattern. Irrigation with W_3 system could stimulate the height of plant to become 117.3 cm, which was significantly higher than W_2 (105 cm) or W_1 system (90.7 cm). The highest result was from the treatment combination of C_3 W_3 (122.3 cm), but it was not significantly different from C_1 W_3 and C_2 W_3. Canopy witdh in pattern C1 (figure 1 b) was higher than that in pattern C2 dan C3, This could be due to the lateral growth was more dominant so that the canopy tended to widen, the opposite from that in C_2 and C_3 pattern (figure 1c and 1d). So, canopy width was affected by available space. SAHID *et al.* (1989) concluded that the canopy width was affected by genetics and environment. He said that if plant population was very close, the canopy was less developed, because of the limited space.

The canopy of cotton in W_3 irrigation system was wider than that in W_1 and W_2. The canopy with 67 cm width was obtained from C_1 W_3 combination. Number of generative branches determined fiber production of cotton. According to HASNAM and SULISTYOWATI (1989) the number of generative branches in monoculture cotton was more than those in polyculture. The number of generative branches at the combination of C_2 W_2, C_1 W_3 and C_2 W_3 was 12.63, 12.44, 12.46 respectively. Apparently, C_1 and C_2 pattern combined with W_3 produced more generative branches.

The number of bolls shedding in C_2 and C_3 patterns was less than that in C_1, in irrigation system W_3 the shedding was less than in the other systems. In C_2 W_3 combination bolls shedding was 1.67 per plant, wheras in C_1 W_1 had 3.19 bolls per plant. According to KRIZEK (1986) shade would affect boll shedding. He also explained that water deficits in generative stage would increase the shedding of squares and decrease the yield.

Table 1. Effect of the number of cotton rows, number of soybean rows, and irrigation systems on vegetative and generative growth of cotton 110 days after planting.

Tabel 1. Pengaruh jumlah baris tanaman kapas, jumlah baris tanaman kedelai, dan sistem pembelian air terhadap pertumbuhan vegetatif dan generatif tanaman kapas pada umur 110 hari setelah tanam

Treatment *Perlakuan*	Plant height *Tinggi tanam* (cm)	Canopy width *Lebar konopi* (cm)	Number of generative branches *Jumlah cabang generatif*	Number of shedding per plant *Jumlah keguguran buah tiap tanaman*
C1S1	101.9 bc	53.5 ab	11.02	2.64 a
C1S2	103.4 abc	55.9 a	12.43	2.30 ab
C1S3	103.5 abc	56.5 a	10.87	2.87 a
C2S1	104.6 abc	54.3 ab	12.07	2.11 b
C2S2	98.8 c	49.2 b	12.61	2.37 a
C2S3	90.3 d	51.6 ab	11.20	1.62 b
C3S1	109.3 ab	50.2 b	11.81	2.13 ab
C3S2	110.6 a	51.7 ab	11.71	2.30 ab
C3S3	109.7 a	50.5 b	11.06	1.78 b
C1W1	89.1 d	43.7 d	10.76 bc	3.19 a
C1W2	101.8 bc	55.3 c	11.70 ab	2.52 ab
C1W3	117.9 a	67.0 a	12.44 a	2.10 b
C2W1	85.8 d	40.9 d	10.67 c	1.94 b
C2W2	103.0 bc	52.2 c	12.63 a	2.49 ab
C2W3	111.7 c	62.0 ab	12.46 a	1.67 b
C3W1	97.1 c	39.9 d	10.43 c	2.17 ab
C3W2	110.3 ab	50.9 c	11.24 bc	2.27 ab
C3W3	122.3 a	61.6 b	11.44 bc	1.78 b
C1	102.9 b	55.3 a	11.63 b	2.60 a
C2	100.2 b	51.7 b	12.25 a	2.03 b
C3	109.9 a	50.8 b	11.04 c	2.07 b
S1	105.3 a	52.7 a	11.44 a	2.30 a
S2	101.1 a	52.3 a	11.96 a	2.32 a
S3	101.2 a	52.9 a	11.53 a	2.09 a
W1	90.7 c	41.5 c	10.62 c	2.43 a
W2	105.0 b	52.8 b	11.86 b	2.43 a
W3	117.3 a	63.5 a	12.45 a	1.85 b
Cotton monokultur *Monokultur kapas*	117.1	58.9	11.1	4.80
C.V. *KK* (%)	7.7	10.4	8.6	40.1

Note : Number followed by the same letter in each column for each anaysis are not significantly different at 5% level DMRT.
C1 = rows of cotton, C2=2 rows cotton, C3=3 rows cotton
W1 = 50% field capasity (0-60 dap) and 75% field capasity (60- 120 dap)
W2 = 75% field capasity (0-60% dap) and 75% field capasity (60- 120 dap)
W3 = 50% field capasity (0-60 dap) and 100% field capasity (60- 120 dap)
S1 = 5 rows soybean, S2=7 rows soybean, S3=9 rows soybean
tn = not significant, n=significant, sn=hight significant

Keterangan :
Angka yang diikuti oleh huruf yang sama pada setiap kolom untuk tiap analisis tidak berbeda nyata menurut uji jarak Berganda Duncan pada taraf 5%
C1 = 1 baris kapas, C2 = 2 baris kapas, C3 = 3 baris kapas
W1 = 50% kapasitas lapang (0-60 hst) dan 75% kapasitas lapang (60-120 hst)
W2 = 75% kapasitas lapang (0-60 hst) dan 75% kapasitas lapang (60-120 hst)
W3 = 50% kapasitas lapang (0-60 hst) dan 100% kapasitas lapang (60-120 hst)
S1 = 5 baris kedelai, S2 = 7 baris kedelai, S3 = 9 baris kedelai
tn = tidak nyata, n = nyata, sn = sangat nyata

Figure 1. Cotton growth in monoculture and mix- cropping with soybean on the low land rice field
Gambar 1. Pertumbuhan tanaman kapas monokultur dan tumpangsari kapas+kedelai di lahan sawah tadah hujan

Growth analysis

Leaf area index (LAI) for C2 and C3 pattern at Tabel 2 were not significantly different with values of 2.01 and 2.00, but they were higher than that of C1 pattern. All values of LAI for W3 were higher that for W2 and W1 irrigation system. Water deficit could decrease the rate of leaf growth. LAI decreases because part of leaves fall prematurely (GUINN *et al.*, 1981).

The values of LAI for combination C1W3, C2W3, C3W3 were 2.45, 2.58, 2.44. Those values were the highest LAI that had been achieved. According to GARDNER *et al.*, (1985), the value of LAI=2 was the optimum value for cotton.

The values of net assimilation rate (NAR) at C1 pattern was 3.05 g/m^2/day, higher than that at C2 and C3 pattern (2.54 and 2.42 g/m^2/day). The greater values of LAI at C2 and C3 pattern stimulated to decrease NAR values. At the same time, W3 irrigation system had the NAR value of 2.529/m^2/day, less than W1 (3.12 g/m^2/day). The shade of lower leaves at the plant with high LAI resulted in decrease of dry weight production per leaf area unit per time unit showed by the decrease of NAR. GARDNER *et al.* (1985) stated that in a plant with high LAI, the younger leaves at the top absorbed more radiation with higher CO_2 assimilation rate. On the other hand, the older leaves at the bottom had a lower CO_2 assimilation rate. Water deficits can decrease leaf growth index, leaf area decrease because of the premature leaves shedding (GUINN *et al.*, 1981). Treatment combinations which produced the highest NAR were C_3S_3 (3.85 g/m^2/day), C_2S_1 (3.72 g/m^2/day) and C_2S_2 (3.27 g/m^2/day).

Table 2. Effect of the number of cotton row, number of soybean row, and irrigation system on cotton growth
Tabel 2. Pengaruh jumlah baris tanaman kapas, jumlah baris tanaman kedelai dan sistem pemberian air terhadap pertumbuhan tanaman

Treatment *Perlakuan*	Leaf area index *Indeks luas daun*	Net assimilation rate (g/m2/day) *Laju assimilasi bersih*	Relative growth rate (g/g/week) *Laju pertumbuhan relatif*	Shoot-root ratio *Nisbah tajuk-akar*
C1S1	1.37 c	1.63 c	0.873 b	3.51 e
C1S2	1.85 abc	2.40 b	0.879 ab	4.94 bcd
C1S3	2.13 ab	3.61 a	0.981 a	5.82 a
C2S1	1.96 ab	3.72 a	0.858 bc	5.69 ab
C2S2	1.77 bc	3.27 a	0.917 ab	5.33 abc
C2S3	2.32 a	2.16 b	0.780 bd	5.05 ab
C3S1	1.99 ab	2.37 b	0.743 d	5.75 d
C3S2	1.90 abc	3.85 a	0.852 b	4.35 d
C3S3	2.12 ab	2.53 b	0.758 cd	4.65 cd
C1W1	1.26a	2.51a	0.860a	4.25 d
C1W2	1.64a	2.50a	0.871a	4.55 c
C1W3	2.45a	2.56a	0.999a	5.48 ab
C2W1	1.44a	2.91a	0.867a	4.90 bcd
C2W2	2.02a	3.01a	0.812a	5.83 a
C2W3	2.58a	2.99a	0.896a	5.33 abc
C3W1	1.53a	2.91a	0.733a	5.07 abcd
C3W2	2.04a	2.90a	0.776a	4.86 bcd
C3W3	2.44a	2.95a	0.835a	4.80 bcd
C1	1.78 b	3.05 a	0.911 a	4.76 b
C2	2.01 a	2.14 b	0.851 ab	5.35 a
C3	2.00 a	2.42 b	0.785 b	4.91 ab
S1	1.77 b	3.17 b	0.825 b	4.98 a
S2	1.84 b	2.77 b	0.883 a	4.87 a
S3	2.19 a	2.57 b	0.840 b	5.17 a
W1	1.41 b	3.12 a	0.816 b	4.74 a
W2	1.90 b	2.86 ab	0.820 b	5.08 a
W3	2.49 a	2.52 b	0.911 a	5.21 a
cotton monoculture *monokultur kapas*	2.36	2.40	0.870	4.03
C.V. (%)	17.0	22.5	7.4	17.7

Note : Number followed by the same letter in each column for each analysis are not significantly different at 50% level DMRT
C-1= rows of cotton, C2= 2 rows, C3= 3rows cotton
W1 = 50% field capasity (0-60 dap) and 75% field capasity (60-120 dap)
W2 = 75% field capasity (0-60% dap) and 75% field capasity (60-120 dap)
W3 = 50% field capasity (0-60 dap) and 100% field capasity (60-120 dap)
S1 = 5 rows soybean, S2= 7 rows soybean, S3= 9 rows soybean
tn = not significant, n= significant, sn= high significant

Keterangan :
Angka yang diikuti oleh huruf yang sama pada setiap kolom untuk tiap analisis tidak berbeda nyata menurut uji jarak Berganda Duncan pada taraf 5%
C1 = 1 baris kapas, C2 = 2 baris kapas, C3 = 3 baris kapas
W1 = 50% kapasitas lapang (0-60 hst) dan 75% kapasitas lapang (60-120 hst)
W2 = 75% kapasitas lapang (0-60 hst) dan 75% kapasitas lapang (60-120 hst)
W3 = 50% kapasitas lapang (0-60 hst) dan 100% kapasitas lapang (60-120 hst)
S1 = 5 baris kedelai, S2 = 7 baris kedelai, S3 = 9 baris kedelai
tn = tidak nyata, n = nyata, sn = sangat nyata

The value of relative growth rate (RGR) at C1 pattern (one row cotton) was higher than C3 (3 cotton rows), but it was different from C2 (2 cotton rows). The highest RGR achieved by combination C1S2, C1S3, C2S2 with the values: 0.879, 0.981 and 0.917 g/m2/week. W3 irrigation system also increased RGR values. KRIZEK (1986) stated that RGR and NAR were affected by CO2 concentration. Cotton as an indeterminate plant is very responsive to CO2 concentration compared to determinate plant. Connected with that idea, it could be concluded that the higher value of RGR at C1 related with CO2 concentration.

Shoot-root ratio (S/R) of C1 was less than that of C2. It was in accordance with LAI value at C1 which was less than C2 and C3. The highest S/R were achieved at the combination of C1W3 and C2W3 with the values of 5.48 and 5.33. Irrigation system and number of soybean rows did not affect the value of S/R. According to MC. MICHAEL (1986), correlation between shoot growth and shoot growth was very complex, and was affected by many factors, e.g. the change of soil temperature, soil humidity and interference of the shoot. At this research, the high values of LAI at C2 and C3 were followed by high values of S/R. The increased value of LAI at W3 irrigation system tended to be followed by the increase of S/R value, although it was not different from W1 and W2.

Fiber yield and quality

The effect of cropping pattern and irrigation system on fiber yield and quality are presented in Tabel 3. The highest yield can be achieved by C3S2 pattern as much as 1,881 kg per ha seed-cotton (Figure 2a) and 715 kg per ha soybean (Figure 2c). Those figures were not different from the result of C3S1 and C2S1 pattern.

Cotton-soybean pattern apparently to produced more than monoculture cotton. Productivity whereas of monoculture cotton was 1 797 kg seed-cotton, monoculture soybean produced 900 kg per ha seed-cotton. C2 cropping system was called skip-furrow-planting (Figure 2b). SIVANAPPAN *et al.* (*in* BEETS, 1982) concluded through his research in India that the yield of cotton in mixed cropping would not decrease compared to single cropping.

The highest average of fiber length was 28 mm resulted from C1W3 and the shortest (26.1 mm) resulted from C1S1. The fiber length was not affected by number of soybean rows but by number of cotton rows. The C2 cropping pattern produced fiber length of 28 mm, longer than those of C1 and C3. The W3 irrigation system produced fiber longer than those of W1 and W2. WANJURA and BARKER (1985) reported that fiber length was more affected by genetic factors and less by environment. Even, the research conducted during three planting seasons revealed that there was no effect of environmental factors on fiber length.

Fiber strength was not affected by number of soybean rows and irrigation system, but was affected by number of cotton rows and interaction between number of cotton rows and irrigation system. Fiber strength from C3 pattern was 84340 psi, stronger than that from C1 and C2.

WANJURA and BARKER (1985) stated that fiber strength was not affected by water deficit. W3 irrigation system produced fiber with 5.46 micronair, more rough than the fiber produced from W1 and W2. The combination treatment C1S1 and C1W1 produced cotton fiber of 4.33 and 4.28 micronair, the most smooth compared with any other pattern.

Economical analysis

It had been explained in discussion that the cropping pattern which produced the yield of cotton and soybean were three cotton rows with seven soybean rows (C_3 S_2) and two cotton rows with five soybean rows (C_2 S_1). They were irrigated by W3 system. The seed cotton produced from those patterns were equal to 2,462 kg per ha and 2,272 kg per ha, land eficiency of land utility increased 4 % compared with monoculture pattern.

Linear programming analysis showed that three rows of cotton with seven rows of soybean irrigated by W3 system was the best pattern with

Table 3. Effectof the number of cotton row, number of soybean row, and irrigation system on yield and quality of cotton fibre
Tabel 3. *Pengaruh jumlah baris tanaman kapas, dan kedelai, serta sistem pemberian air terhadap produksi dan kualitas serat*

Treatment Perlakuan	Yield *hasil*		Fiber quality *kualitas serat*		
	Cotton+soybean *Kapas+Kedelai* (kg/ha)	Cotton equivalent *Setara kapas* (kg/ha)	Length *Panjang* (mm)	trength *Kekuatan* 1000 psi	Micronair *Kehalusan*
C1S1	1.229 + 722	1.817 c	26.75 c	80.15	5.18 a
C1S2	1.312 + 599	1.800 c	27.50 ab	78.77	4.33 b
C1S3	1.521 + 716	2.118 b	27.50 abc	80.96	5.10 a
C2S1	1.697 + 708	2.272 ab	27.50 ab	83.27	5.39 a
C2S2	1.640 + 692	2.202 b	26.10 a	82.38	5.20 a
C2S3	1.418 + 846	2.106 b	27.20 ab	82.61	5.24 a
C3S1	1.814 + 581	2.286 ab	27.50 ab	82.50	5.21 a
C3S2	1.881 + 715	2.462 a	27.00 b	82.34	5.22 a
C3S3	1.160 + 758	1.777 c	27.00 b	86.19	5.39 a
C1W1	1.059 + 481	1.450 f	26.50 d	79.92 cd	5.02 cd
C1W2	1.337 + 666	1.878 e	27.20 abcd	76.62 d	4.28 d
C1W3	1.667 + 891	2.407 bc	28.00 a	82.81 abc	5.31 abc
C2W1	1.238 + 567	1.700 e	27.50 abc	85.69 ab	5.18 bd
C2W2	1.597 + 722	2.184 d	27.50 abcd	81.61 bc	5.24 bcd
C2W3	1.920 + 956	2.697 a	28.00 ab	80.92 bcd	5.41 ab
C3W1	1.401 + 567	1.862 e	27.20 bcd	83.96 abc	5.20 bc
C3W2	1.656 + 692	2.219 cd	27.00 cd	86.88 a	4.98 d
C3W3	1.798 + 795	2.444 b	27.50 abc	82.19 abc	5.64 a
C1	1.354 + 679	1.912 b	27.20 b	79.77 b	5.20 a
C2	1.585 + 748	2.193 a	28.00 a	82.77 b	5.28 a
C3	1.618 + 685	2.175 a	27.50 b	84.34 a	5.27 a
S1	1.580 + 670	2.125 a	27.20 a	81.96 a	5.26 a
S2	1.611 + 669	2.155 a	27.50 a	82.50 a	5.25 a
S3	1.367 + 774	2.000 a	27.20 a	82.42 a	5.24 a
W1	1.233 + 538	1.671 c	27.20 b	83.19 a	5.13 b
W2	1.530 + 693	2.093 b	27.20 b	81.71 a	5.17 b
W3	1.795 + 881	2.516 a	28.00 a	82.00 a	5.46 a
cotton monocultere *monokultur kapas*	1.797	1.797	27.00	83.80	5.90
Soybean *kedelai*	900	730	-	-	-
CV KK (%)		10.0	1.8	3.6	33.5

Note : C-1= rows of cotton, C2= 2 rows cotton, C3= 3 rows cotton
W1 = 50% field capasity (0-60 dap) and 75% field capasity (60-120 dap)
W2 = 75% field capasity (0-60% dap) and 75% field capasity (60-120 dap)
W3 = 50% field capasity (0-60 dap) and 100% field capasity (60-120 dap)
S1 = 5 rows soybean, S2= 7 rows soybean, S3= 9 rows soybean
Number followed by the same letter in each column for each analysis are not significantly at 5% level DMRT.

Keterangan :
C1 = 1 baris kapas, C2 = 2 baris kapas, C3 = 3 baris kapas
W1 = 50% kapasitas lapang (0-60 hst) dan 75% kapasitas lapang (60-120 hst)
W2 = 75% kapasitas lapang (0-60 hst) dan 75% kapasitas lapang (60-120 hst)
W3 = 50% kapasitas lapang (0-60 hst) dan 100% kapasitas lapang (60-120 hst)
S1 = 5 baris kedelai, S2 = 7 baris kedelai, S3 = 9 baris kedelai
Angka yang diikuti huruf yang sama pada setiap kolom untuk tiap analisis tidak berbeda nyata menurut uji jarak Berganda Duncan pada taraf 5%

Figure 2. Cotton and soybean yields in multiple cropping with furrow irrigation system on the lowland rice field
Gambar 2. Penampilan hasil kapas dan kedelai dalam pola tumpangsari dengan sistem pengairan alur terbuka di lahan sawah tadah hujan

an opti- mum profit of Rp 1,308,767 per ha per year. This optimum profit obtained from rice-1 farming was Rp 480,433 and from cotton + soybean farming was Rp 828,333 per ha per year.

The different optimum profits obtained from those patterns was caused by different yields of cotton and soybean, as well as the input used.

It was apparent that seeds, fertilizers, insecticides and labour used in pattern of three cotton rows and 7 soybean rows was Rp 776,136 per ha, less than input of two cotton rows and five soybean rows pattern (Rp 894,950,-). From those differences, the labour used for those two patterns were 220.9 and 251.7 mandays per ha. It happened because of the easiness of operational system in the field e.g. planting, fertilized application, weeding, pest control and harvesting. This is in accordance with BEETS idea (1982) that in a certain combination, number of plants would give an easyness for weeding, pest control, fertilized application and irrigating, and at last the labour usage would decrease and productivity should increase. The value of subsidation was less than imaginative input value, and resulted in a non optimum profit. In other words, to maintain optimum condition, the value of subsidation for farmers might not be less then imaginative input value.

CONCLUSION AND SUGGESTION

Cotton + soybean cropping pattern at lowland of rainfed area was one of methods to increase cotton productivity. The best pattern that

Table 4. Optimum analysis based on linier programme for two and three rows cotton irrigation with W3 system.
Tabel 4. Analisis optimal menurut program linier untuk pola tanam dua baris kapas, dan tiga baris kapas yang diairi dengan sistem pengairan W3

Specification *Uraian*	Cropping pattern *Pola tanam*			
	2 rows cotton + 5 rows soybean *dua baris kapas dan 5 baris kedelai*		3 rows Cotton + 7 rows soybean *tiga baris kapas dan 7 baris kedelai*	
	Volume	Rp.	Volume	Rp.
Production per ha *Produksi*				
Rice-1 Padi-1	3600 kg	900 000	3 600 kg	900 000
Cotton equivalent *Setara kapas*	2272 kg	1 647 200	2 462 kg	1 784 950
Input per ha				
Rice-1 *Padi-1*		410 432	410 432	
Cotton+Soybean *Kapas+Padi*				
Cotton seed *Benih kapas*	11.8 kg	17 700	14.5 kg	21 750
NPK fertilizer *Pupuk NPK*	550.0 kg	132 000	433.9 kg	104 136
Pesticides *Obat-obatan*	5.81	116 000	4.91	98 000
Labours *Tenaga kerja*	251.7 HKP	629 250	220.9 HKP	552 250
Profit per ha *Keuntungan*		1 241 818	1 308 767	
Rice-1 *Padi-1*	1824 kg	456 224	1 921 kg	480 767
Cotton+Soybean *Kapas + kedelai*	1084 kg	785 960	1 142 kg	828 333
Shadow price of input *Harga bayangan input*				
Cotton seed *Benih kapas*	1 kg	1 500	1 kg	1 500
NPK fertilizer *Pupuk NPK*	1 kg	240	1 kg	240
Pesticides *Obat-obatan*	1l	20 000	1l	20 000
Labours *Tenaga kerja*	1 HKP	2 500	1 HKP	2 500

HKP= Man days *Hari kerja pria*

could be used with strip cropping was a combination between 3 rows of cotton and seven rows of soybean, irrigated by 50 % of field capacity at the age of 0-60 days, followed by irrigating 100 % field capacity at the age of 60-120 days after planting. This irrigation system increased generative branches and surviving bolls and decreased boll shedding, and lastly increased the production.

It is necessary to complete the research on cotton + soybean farming at lowland of rainfed areas and the possibility that might be appear e.g. the change of pest status and certain conditions affecting the fiber quality.

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