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Overview of Farmers' Perceptions of Current Status and Constraints to Soybean Production in Ratanakiri Province of Cambodia

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Abstract: A study was undertaken in Koun Mom district of Ratanakiri province in Cambodia to analyze the perceptions of the current status and constraints to soybean production and identify solutions to improve production and the management practices. Primary data were collected by personal interviews at field level of 130 producers. Most respondents were in the medium age category, Grade 4 education, with an average land holding of 2.96 ha and annual income of KHR 6,195,548 Riels (about 1548 USD). In terms of economic and production constraints, the high cost of fertilizers, severe insect and disease infestation, were identified as most important. Association with independent characteristics and scientific orientation were not significant, but education, land holding, annual income, socioeconomic status, and risk preference were significantly associated with constraints to soybean production. Within the context of sustainable agricultural production practices, it is suggested to improve high-yielding genotypes, ensure timely availability of high-quality seeds, and identify appropriate crop management practices (planting dates, planting density, nutrient and water management practices) and find ways to efficiently and effectively disseminate information to farmers to enhance soybean production in the region. In addition, extension agents and other agencies should provide soybean farmers marketing information, establish viable links between farmers and relevant stakeholders and private sector to improve access to inputs and modern technologies while the local and state governments should establish rural markets with good market infrastructure to enable farmers have high returns from soybean production.

Keywords: constraints; sustainable; socio-economic; cultivation; soybean; production; Cambodia

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1. Introduction

Soybean (*Glycine max* L. Merril) is an important food security crop in Asia, it is also one of the most common crops traditionally and commercially grown in upland areas on different soil types and under a wide range of climate conditions. Soybean is a native of eastern Asia and originally grew wildly in China, Manchuria, Korea, and Japan [1]. Soybean production both in terms of area and total production has grown steadily since 1980 and reached 108,704 ha with a total production of 175,977 tons per year in 2019 [2]. In recent years, soybean production has increased in north-western Cambodia, especially in the provinces of Battambang, Siem Reap, Kandal, and Takeo [3]. However, the main production area for the past five years has been in the provinces of Ratanakiri and Preah

Vihear [4]. In the past, most farmers grew soybean mainly for subsistence, on a small scale, and as supplementary crop for livelihood. However, soybean has now become the main cash crop and the fourth most important crop after rice (*Oryza sativa* L.), maize (*Zea mays* L.), and cassava (*Manihot esculenta* Crantz.) in terms of cultivated area and production. With improved technologies, most farmers are now shifting from traditional varieties to improved varieties such as DT84, B3039, and Chiang Mai 60 which are the varieties that have been tested in Cambodia agroecological zones and performed well in growing conditions and produced high yield [3].

Based on the land profile of Cambodia, many regions has well-drained, loamy soils that are suited to soybean production. Such soils are also suitable for a wide range of other crops, so the decision to grow soybean will depend on its profitability relative to other crops and availability of suitable crop management practices. According to Befield et al. [5] most of the provinces in Cambodia grow soybean. However, the main production region based on the report of the National Institute of Statistic [6] indicated that five in every ten agricultural holdings in the Plateau and mountainous zone of Cambodia were engaged in growing soybeans. About 92% of these soybean growers were located in two provinces: (a) Ratanakiri (52%) in which the holdings in the District Koun Mom specifically in Communes Ta Ang, Teun and Trapeang Chres shared the biggest proportions of growers; and (b) Preah Vihear (40%) where soybean growers in Communes Chamraen and Ro'ang of District Sangkum Thmei were located. The remaining provinces include Kratie (4%), Srung Treng (3%), and Mondulkiri (1%).

The decline of soybean production and poor yields may be attributed to the production problems being encountered by farmers, these include low plant population per hectare for several cultivars of the crop, availability of improved seeds, poor germination cause by quick loss of seed viability, shattering of pod, drought stress, and poor nodulation among other factors [7]. Furthermore, farmers experienced loss of soybean viability after 12 months of storage, which means that farmers cannot have access to good seeds for planting [8]. Berglund and Helms (2003) [9] reported that row spacing is a critical determinant of yield in soybean production, because appropriate spacing can ensure effective weed control and efficient use of resources. Grau et al. (2004) [10] reported that plant health is a critical component of profitable soybean production, and that plant pathogenic fungi are important group of disease organisms affecting soybean health. The most important insect pests of soybean are defoliators or pod feeders; these two groups of insect pests can reduce soybean yield up to 65% [11]. According to Sanginga et al. (1999) [12], the main constraints on soybean production include limited access to germplasm collections leading to lack of improved varieties suitable for the country, poor soil fertility, climate variability, pests and diseases, poor access to quality seeds, and limited skills of best agronomic practices. Kandil et al. (2013) [13] observed that differences in root and shoot length and root/shoot ratio in soybean may be affected by environmental factors such as light, water, and the type and amount of nutrients available or applied. Inappropriate marketing and market information lead to low price [14]. Labor is the most critical resource in agricultural production in developing countries during the production process and in the harvesting and post-harvest activities [15].

The average yield of soybean in Cambodia is 1.619 t ha^{-1} which is low compared to global average of 2.769 t ha^{-1}. However, with good genotypes and crop management practices soybean yield in Cambodia can exceed 3 t ha^{-1}. The optimal temperature for soybean growth and yield is between 20 and 30 °C. Temperature above 35 °C limits growth and yield of soybean [16]. In Cambodia, much of the production of soybean is concentrated in the main wet season from May to October, when the risk of high temperature and water deficit stress is lower, compared to early wet season or summer. High temperatures can exceed the optimum limits in the early wet season and can also cause water stress conditions; therefore, it is not suitable for soybean production. Soybean can be grown to maturity with as little as 180 mm, but such water stress conditions reduce yield by 40–60% compared with optimal conditions [17]. Long-term changes to normal environmental conditions, such as rising sea level, shifting rainfall seasons, and temperature extremes alter crop patterns and long dry periods are gradually undermining crop production and livelihood [18]. In recent years, soybean production in Cambodia is increasing due to competitive market prices and demand from consumers, but in the Ratanakiri Provinces, production and yield remain low. Improvement of soybean production and management may aid in providing additional opportunities for the farmers to support their livelihoods and contribute to income generation. However, there has not been a systematic evaluation of current status and perceptions of farmers on current status and constraints to soybean production and opportunities for soybean production and yield improvement. It is critical and important to understand these key issues from both biophysical and social science perspectives. Such information will be critical to researchers, government sector, private sector, extension agencies, and policy makers to develop appropriate technologies to enhance soybean production and create an enabling environment of successful cultivation of soybean in the region. Therefore, the objectives of this research were to (a) document farmers perceptions on current status of soybean production; (b) determine key factors influencing farmers decisions and constraints or problems to produce soybeans; and (c) suggest some key opportunities and suggestions that can improve soybean production in the Ratanakiri Province of Cambodia.

2. Materials and Methods

2.1. Study Area

The study was conducted in Ratanakiri province of Cambodia located in the northeast of the country. This province is well-known for upland/highland rice production, it stands about 500 m above sea level, and is one of the most attractive places for visitors because of its waterfalls and evergreen forests. Ratanakiri province covers about 10,782 km^2 and is composed of nine districts, namely, Andaoung Meas, Bar Kaev, Koun Mom, Lumphat, Ou Chum, Ou Ya Dav, Ta Veaeng, Veun Sai, and capital Ban Lung. The total population in Ratanakiri has increased from 191,297 in 2012 to 201,547 people in 2018. This fast-growing population is the result of the increasing tourism activities and services such as hotels, restaurants, and commercial industrial plantations (e.g., cassava, rubber (*Hevea brasiliensis*)), among others. All these activities resulted in a faster than predicted population growth rate [19]. About 70% the province's population belongs to the indigenous people such as the Phnong, Stieng, Tompoun, Charay, Kroeung, Kavet, Lun Kachak, and Praov. The most profound indigenous groups with high population are in the Tompuon (33,506), Charay (24,834), and Kroeung (22,122). Agriculture is an important booster for provincial economy. In 2011, the majority (about 83.22%) of the total households in this province relied on agriculture as their main source of income where 76.31% were rice producers. On the other hand, other agricultural sectors including long duration perennial crops [rubber (*Hevea brasiliensis*), cashew nut (*Anacardium occidentale)* coffee (*Coffee arabica*), fruit trees etc.], annual crops (legumes, maize, cassava, etc.), vegetable grower, fisheries, livestock, and natural traditional forest product collection can also be seen in the province [20].

2.2. Data Collection

This research was conducted in Ratanakiri province in September 2019, at Koun Mom District with the coordinates 13°44′ N, 107° E (Figure 1). It is located around 531 km from the Phnom Penh, the capital city of Cambodia. It shares border with Mondulkiri, Stung Treng province, and the countries of Laos and Vietnam.

Among the five communes of Koun Mom district only two communes (Teun and Trapeang Chres) were selected as the sample communes in the study because these communes were the main production sites of the district in terms of planted area. A total of 130 selected farmers who grow soybean were interviewed. The harvested yields of soybean in Cambodia from 2015 to 2019 are presented in Table 1. Similarly, the distribution of sample respondents from different communes are shown in Table 2.

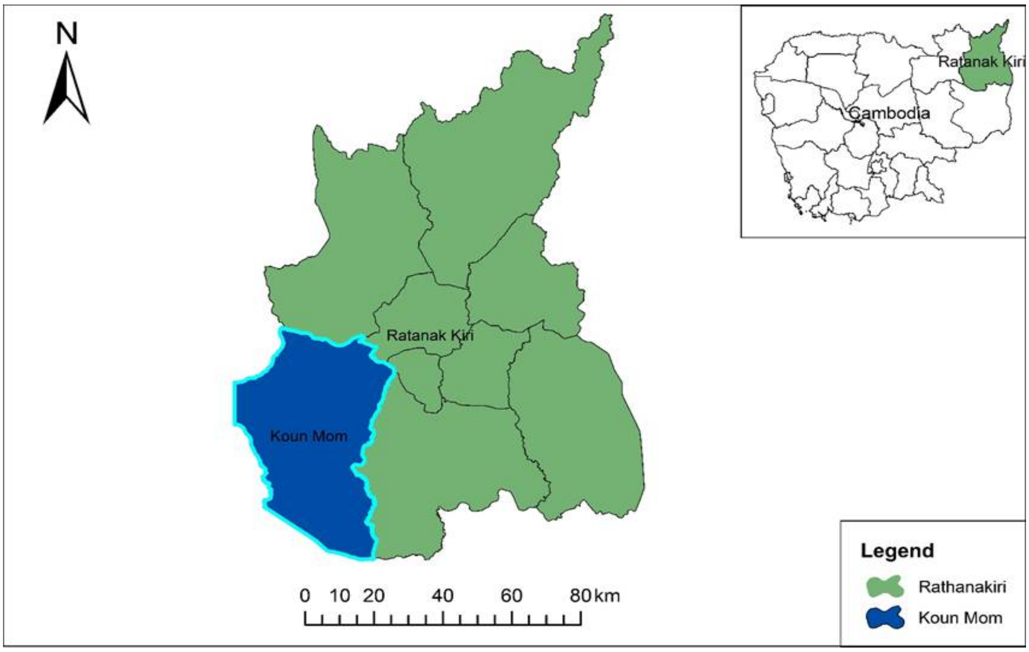

Figure 1. Map of Cambodia, showing the study area and region and district of study area. Source: Department of Land Management and Rural Planning of Ratanakiri Province (2019).

Table 1. Yield and harvested area of soybean in Cambodia, 2015–2019 (FAO, 2020) [2].

Year	2015	2016	2017	2018	2019
Harvested Area (ha)	102,000	102,000	104,000	105,000	108,704
Total Production (t)	162,000	162,000	168,000	170,000	175,977
Yield (kg ha^{-1})	1588	1588	1654	1619	1618

Table 2. Distribution of sample respondents in Koun Mom District, Ratanakiri Province, Cambodia.

Location	Producer Samples
Koun Mom District	130 Total
Teun Commune	68
Trapeang Chres Commune	62

Both primary and secondary data were used in this study. Primary data were collected from the farmers who were interviewed, focus group discussions, and survey questionnaire with closed and open-ended questions. Respondents were asked about their perceptions on soybean production and farmers' personal characteristics, farm income, farmland crops production, cost and return, sale price, planting advice, and main problems of growing soybean. This was conducted with structured questionnaires delivered by interviewers at two communes (Teun and Trapeang Chres) in September and December 2019 to collect data from individual farmer of soybean production in the cropping season. Because soybean was mostly cultivated in these communes, the 130 respondents cultivated soybean in the 2018 cropping season from June to November. Farmers were randomly selected to ensure accurate representation of data in the district. At each village, questionnaires were administered face-to-face to the head of household. Respondents were asked about their willingness to cultivate soybean, farmers' personal characteristic, basic household information, land tenure and management, production practice and technology adoption, input information, output information, farm income, crop production, sale price, planting advice, technical assistant, main problems of growing soybean, market information, storage and processing information, and farmers' perception. Informal interviews were also held with key performance particularly regarding land tenure outside the questionnaire interviews. Secondary data were collected from the Ministry of Agriculture, Forestry and Fisheries (MAFF), Provincial Department of Agriculture, Forestry and Fisheries (PDAFF), District Administrative Office, and Food and Agriculture Organization of the United Nations (FAO). In addition, secondary data were also collected from other sources such as books, publications, and journals. Some information was obtained from the commune offices as well as from village chiefs and other government officers who have access to information. The total number population in Teun and Trapeang Chres communes were 550 and 625 families, respectively. The total number of households who planted soybean were 135 and 175 families, respectively.

2.3. Method and Data Analysis

The Statistic Package for Social Science (SPSS) 16.0 and Microsoft Excel 2010 were used for both qualitative and quantitative data analyses to address the objectives. The responses of the interviewed and quantitative data analysis were recorded, summarized, and analyzed using the abovementioned software package. Multiple regression analysis was also used for predicting the main effect of multiple factors on the yield of soybean based on the value of other variables and determine the overall fit (variance explained) of the model and the relative weight of each of predictors to the total variance explained. A standard survey and sampling method [21] was used as described below.

Initial sample size:

$$n_1 = \frac{Z^2 \hat{P}(1-\hat{P})}{e^2}$$

n_1: First Sample Size
Z: A value corresponding to a desire level of confidence
$\hat{P}$: Percentages instead of proportion
e : A desired margin of error
where Z5% = 1.96 => $(19.6)^2$ = 3.84
$\hat{P}$: 50% = 0.50
$1 - \hat{P}$ = $1 - 0.50$ = 0.50
e : 10% => $(0.1)^2$ = 0.01
n_1: 96 families

Adjust for the sample size:

$$n_2 = n_1 \frac{N}{N + n_1}$$

n_1: First Sample Size
n_2: Adjustment for the size of the population
N : Total number of households

For Teun Commune:

$$n_2 = 96 \frac{135}{96 + 135}$$

$$n_2 = 56 \text{ families}$$

For Tropeang Chres Commune:

$$n_2 = 96 \frac{175}{96 + 175}$$

$$n_2 = 61 \text{ families}$$

Effect of sample design:

$$n_3 = deff \times n_2$$

n_2: Adjustment for the size of the population
$deff = 1$: Design effect for sample random sampling design

For Teun Commune:

$$n_3 = deff \times 56$$

$$n_3 = 56 \text{ families}$$

For Tropeang Chres Commune:

$$n_3 = deff \times 61$$

$$n_3 = 61 \text{ families}$$

Total number of samples:

$$n = \frac{n_1}{r}$$

n: Total number of samples
r: Degrees of freedom (%) = 90%

For Teun Commune:

$$n = \frac{56}{0.90}$$

$$n = 62 \text{ families}$$

For Tropeang Chres Commune:

$$n = \frac{61}{0.90}$$

$$n = 68 \text{ families}$$

Multiple regression model: $y = b_1x_1 + b_2x_2 + \ldots + b_nx_n + c$.

Y_i = dependent variable

Here, b_i's ($i = 1, 2, \ldots, n$) are the regression coefficients, which represent the value at which the criterion variable changes when the predictor variable changes.

c = possible impact of independent variable exerted on the dependent variable.

3. Results and Discussion

3.1. Descriptive Statistics

The descriptive statistics for the full sample of farmers (n = 130) is presented in Table 3. These descriptive data variables were used in the regression model. The explanatory variables were land acquisition means, planting advice or continue variables (e.g., household size, farm size, farming experience, and soybean price).

3.1.1. Gender of Main Person Responsible for Soybean Production

Division of labor, inequality, and differences in power structure between men and women or boys and girls are quite complicated in Cambodia. Large differences exist between urban and rural societies. In the agricultural sector, women provide greater share of agricultural workforce. Women spend approximately the same amount of time in wage employment as men. Men's tasks include those considered to involve considerable physical effort, such as tillage activities (plowing, discing, and furrowing) and herbicide application [22]. Whereas, women's tasks include transplanting, weeding, irrigating and other field operations that are relatively not considered to be physically demanding. Moreover, women carry more responsibilities in housework and taking care of children and are usually responsible for managing food security in the family, ensuring that there is sufficient food available every day [23,24]. Even though women take on equal or more responsibilities than men in terms of wage, employment, and hours spend, during the interview the respondents said that the man is the main person that takes the lead in agricultural activities. As presented in Table 3, men (66%) acted as the main person responsible in leading the soybean farming activities while women did so in only 34% of the cases. Cases involving women as main actors instead of men in soybean production were primarily widows or those whose husbands were absent (not living within the household) or had a disability. Women also worked in the field since there is not enough labor to help in field work. This indicates that there is significant gender bias in agriculture. Similar observations were made in previous research [25–28]. Men also recognized women for their household activities including washing, cooking, cleaning, and childcare. Gender is key to who does what in home and field and understanding the potential effect on rural livelihoods [29]. Women have greater control over activities associated with in the home while both men and women reported that it is important for the husband and wife to be involved in field-related decisions; however, women's roles and responsibilities influence participation in the field could impact household decisions [30].

Table 3. Description of variables used for farmers interviewed in Koun Mom District, Ratanakiri Province, Cambodia (*n* = 130; 2019).

Variables	Description	Categories	Frequency	Percentage	Median
Gender of person responsible in farming	Male Female	Men who join in farming Women who join in farming	86 34	66 34	
Age	Age of farm head (year)	19–30 = 1, 30–40 = 2, 40–50 = 3, 50–60 = 4, >60 = 5	27 43 37 18 5	20.8 33.1 28.5 13.8 3.8	2.0
Education	Education of household head (year)	Primary school = 1, secondary school = 2, high school = 3, complete college = 4	102 20 8	78.5 16.4 6.2	1.0
Household size (person)	Number of family members	1–5 = 1, 6–10 = 2, >10 = 3	94 35 1	72.3 26.9 0.8	1.0
Farming labor	Number of family members engaging in farming (more than 16 years old)	1–5 = 1, >6 = 2	122 8	93.8 6.2	1.0
Soybean production area (ha)	Total land for soybean production	0–5 = 1, 6–10 = 2, >10 = 3	120 9 1	92.3 6.9 0.8	1.0
Other crop production (ha)	Land for other crops	0–5 = 1, 6–10 = 2, >10 = 3	117 11 2	90.0 8.5 1.5	1.0
Farming experience (year)	Year of planting crop	0–5 = 1, 6–10 = 2, >10 = 3	30 59 41	23.1 45.4 31.5	2.0
Soybean growing season	Rainy season or dry season	Dry season = 0, rainy season = 1	0 130	0 100	0.0
Technical assistance	Farm operator is in contact with an agro-technician	Yes = 1, no = 0	32 98	24.6 75.4	0.0
Land acquisition means	Whether to renting land	Yes = 1, no = 0	6 124	4.6 95.4	0.0
Irrigation facilities	Status of irrigation facilities	bad = 1, neutral = 2, good = 3	80 34 16	61.5 26.2 12.3	1.0
Planting advice	Farm operator is in contact with an agricultural advisor	Yes = 1, no = 0	30 100	23.07 76.93	0.0

3.1.2. Age of Household Head

Age is one of the characteristics important in describing the households and can provide a clue as to the age structure of the sample and the population who are currently engaged in soybean production. Increase in farmers' age also increases farmer's experience in farming as well as increasing the awareness of the benefits of specific technology. The average age of farmers was 40 years and ranged from 22 to 73 years (Table 3). According to Enete and Igbowe [31], the age of household head is a proxy measure of experience in managing a household's business to generate income and availability of resources for the family. It is also possible that older and more experienced household heads can make better production decisions. The implication is that farmers who have more years' farm experience are more likely to adopt soybean production technologies than those farmers who have a smaller number of years of farm experience. However, it is also the reflection of lack of engagement of youth in agriculture and in some instances younger farmers may be more open to innovations in crop production rather than using traditional practices. These positive relationships with age were reported in other studies [32,33].

3.1.3. Education of Household Head

The formal education system in Cambodia is graded as: primary, secondary, and high school. Students have the privilege of registering for schooling which starts from Grade 1 at the age of six years. Primary school is between Grades 1 to 6; secondary school is from Grade 7 to 9, and high school is from Grade 10 to 12. To complete the basic foundation of formal education, an individual student receives at least 12 years of schooling. From the results of this study, it was observed that some farmers did not have any formal education and few of them reached high school level (Table 3). The results indicate that the average length of schooling was four years; the majority of farmers were able to complete only primary school.

The average experience of producers in soybean production was 9.76 years which is low compared to their average age of 40 years. According to the village chiefs, some farmers were new settlers while some just have shifted to soybean crop cultivation because it is better than to keep the land free and clean the weeds while they grow between cassava and cashew nut. In addition, soybean market price was higher compared with other crops. A similar study by Nahayo et al. [34] also indicated that experienced farmers were more likely to rely on the traditional farming practices than the less experienced ones. After all, new crops mean new risks, and experienced farmers are willing to expand a familiar crop. In this study area, soybean is a familiar crop for commercial farmers and this area is suitable for planting soybeans.

3.1.4. Household Size

Household members are the main source of human capital for the family as well as for the society. Households with several members indicate higher advantage on labor for income generation over those who have fewer members. In the case of farm activities, families with fewer members had to hire additional labor compared to bigger-sized families. Results of this study revealed that growers have an average of five persons per household and the range is from two to nine persons. Normally, the larger the household size, the more likely the household is to become successful as the household has more labor to work on the farm [35,36]. However, it will require more resources to support and provide food.

3.2. Farmers' Perceptions

The survey result showed that 41.52% of farmers land area was for soybean planting and the farmers said that they would consider growing other crops since the soybean crop price had been low in recent years. Moreover, 58.48% of farmers' land is for planting other crops because soybean price last year (2018) was too low, and the soybean producer did not have enough budget for their production and there was no subsidy to offset the losses. Most farmers said that they had not received loan for their production, because the interest rate was high, and application for loan required many documents to make sure that farmers will pay on time and not default.

3.3. Profit Analysis of Soybean Production

Difference in farm practices, cost of inputs, cost of labor, and cost of products sold will cause difference in production costs, returns and profitability of crop production. Table 4 shows the analysis of profit from soybean production in monocropping and intercropping system. Soybean production yield per hectare was 1552.49 kg ha^{-1} and 1443.83 kg ha^{-1} in intercropping (cashew nut, with soybean) and monocropping system, respectively. The average price of soybean grain was 1579 Riel (0.39 USD) per kg in both cropping systems. Based on the calculation, the gross revenue of soybean per hectare was 2,451,381 and 2,279,807 Riels, respectively. The average cost of material inputs per hectare such as seeds and pesticides was 164,780 Riels, followed by labor cost for land preparations, plantation, weeding, spraying, and harvesting, with a total of 1,176,652 Riels in intercropping which was relatively lower than monocropping system which had 169,966 Riels for the material inputs and 1,201,233 Riels for the labor cost. This resulted in relatively higher gross profits in the intercropping system (949,969 Riels) when compared to the monocropping system (908,607 Riels).

Table 4. Producer's profit from soybean production per hectare basis, Koun Mom District, Ratanakiri Province, Cambodia (2019). All data is in KHR Riels. (1 USD is 4000.53 Riels, 12 March 2021 conversion rate).

Items	Intercropping	Monocropping
1. Gross Revenue		
Yield of Soybean (kg ha^{-1})	1552.49	1443.83
Price of Soybean (Riel kg^{-1})	1579.00	1579.00
Total Revenue	2,451,381.71	2,279,807.57
2. Production Cost		
Inputs		
Seed	Previous Season	Previous Season
Herbicide	164,780.00	169,966.67
Fertilizer	Not Applied	Not Applied
Sub-Total	164,780.00	169,966.67
Labor		
Land Preparation	208,352.27	226,400.00
Planting	311,850.00	321,666.67
Weeding	Use Herbicide	Use Herbicide
Fertilizer Application	Not Applied	Not Applied
Spraying	131,700.00	96,166.00
Harvesting	523,750.00	557,000.00
Sub-Total	1,176,652.27	1,201,233.34
Total Cost	1,505,412.27	1,371,200.01
3. Gross Profit (1–2)	949,969.44	908,607.56

There were yield differences between monocropping and intercropping system, but both levels were low. Possible constraints of the overall low yield among the respondents were examined. The responses ranged from lack of availability and use of technologies, timely availability of quality inputs, wide range of planting time from June to August. Soybean seeding rates for the various land areas cultivated were more than the recommended rate of 37.5 kg ha^{-1}. Seeds for planting were mainly obtained from their own field or from the local market and stored, but often improperly preserved or stored. Farmers stored soybean for periods ranging from one to six months. Sixty-nine percent of farmers did not practice any pest and disease control on their farm. Marketing of farm produce by farmers in Ratanakiri is determined by traders, who do not have well-defined sources. These traders usually come from the towns to trade agricultural outputs. The interviews revealed that farmers did not have in place other market channels such as marketing organizations or groups to determines price or arrange for convenient market with processing companies to attract quick and reasonable prices for their produce.

For soybean production in Koun Mom district, farmers do not need to hire the labor as they ask for help from their neighbors when they plan to grow the soybean. When the turn of their neighbors for growing come, they help them back to produce soybean. Moreover, during the growing season, farm owners do not need to feed them; helpers bring their own water and food. This makes the soybean production convenient and ensures that labor is available for crop production.

3.4. Factors Influencing Soybean Production and Problems Encountered by Farmers

Factors influencing soybean production varied by age, household, and seed. Interviews suggested that older farmers have a greater likelihood of high production. Cambodia is now in the stage of urban development, and more and more young farmers are moving to the city. Householders will consider the shortage of labor force in agricultural production and reduce the cultivation of labor-intensive crops [37]. Elderly farmers have cultivated soybean for many years, and now the farmers in Ratanakiri are growing soybean between the cashew nut trees to control weed growth while having additional yield at the same time. The results of the multiple regression are presented for key factors in Table 5. This analysis shows the influence of explanatory variables.

Table 5. Multiple regressions of estimates of the factors affecting the farmers' soybean production in Koun Mom District, Ratanakiri Province, Cambodia (2019).

Variables	Coefficient	Probability Value
Household size	0.062	0.100
Members in farm	0.057	0.145
Farming experience	0.013	0.124
Land size (ha)	0.021	0.831
Year of soybean cultivation	0.0038	0.182
Soybean price/kg	0.0003	0.0225 *
Planting cost	0.247	0.30

Significance level of * indicate $p < 0.05$.

According to the analysis, soybean price/kg is a significant ($p < 0.05$) and important factor influencing the decision on producing soybean (Table 5). There was no significant ($p > 0.05$) influence of household size, members in the farm, farming experience, land size, and years of soybean cultivation or cost planting. This clearly shows a strong farmer preference for the crop is based on price, marketing opportunities and income generation. The low price of soybean and high expenditure affects the profit margin from production which can adversely influence farmers' soybean production. Price fluctuation within the season is a big problem for soybean production in the study area and the trend of soybean price was noticeably higher during the early harvesting period and decreased gradually during the peak of harvesting period. These findings were similar to those observed by Deese and Reeder [38] that soybean price heavily influenced on the soybean production which resulted in improved competitiveness and significant increases in planted area and exports. Caldas et al. [39] found that uncertainty of financial returns decreases planting behavior in Ratanakiri province, and that farmers change to a new crop if the crop is more marketable and brings more income to their family. The case studies of Abdulai [40] in Zambia and of Himmelstein et al. [41] in Africa found that intercropping systems increase crop yield by 23% and farm revenue by $172 per hectare. This result is corroborated by Mandryk et al. [42] who reported that farmers' practical decisions were mostly driven by economic profit. Soybean price was low during their harvesting time because the product trading of farmers in rural Ratanakiri province is determined by traders. The interviews revealed that farmers did not have in place other market channels such as marketing or cooperative groups to determine prices. The traders took advantage of this and exploited the farmers, offering a low price to make their own profit. These results agree with previous findings that small-scale farmers lack access to price information from local, regional, and national markets which lack access to markets [43,44]. The result suggests that farmers' objective is to maximize profits and to plant crops with guarantee income. According to FAO [45], the soybean subsector is hugely immature with limited or no links in the value chain from production to marketing to processing. The demand for soybeans and its by-product is small. The subsector does not encourage farmers to invest in production because of a weak market linkage. However, this is changing due to large demands from other countries in the regions, particularly China, and will influence the markets.

Farmers commonly stored their soybean seed in airtight plastic and cover with a bag outside to prevent moisture absorption and deterioration of the seed in storage. However, seed deterioration could still have been caused by exposure to sunlight because the farmers often did not have appropriate storage places for their farm produce. The poor quality of the product likely led the firms and traders to offer low prices to compensate for any potential profit losses.

Table 6 shows that 25.38% of farmers have limited knowledge in soybean production. Farmers did not know how to plant in rows and determine the plant population per unit area and growing with a low population (wide spacing) can adversely influence the total yield of a given area. However, some of the soybean farmers interviewed agreed that those who plant with machine or row received higher yields if other cultural practices were performed well. Berglund and Helms [9] who reported that row spacing is a critical determinant of yield in soybean production, because it ensures effective weed control. Poor agronomic practices, small-scale household cultivations, and lack of high yielding varieties are common constraints in other countries like Uganda [46]. The Royal Government of Cambodia have made development of market economy, economic diversification and private sector as key component of National Strategic Development Plan [47].

Table 6. Problems encountered by soybean producers in Koun Mom District, Ratanakiri Province, Cambodia (2019).

Problems	Sample Respondents				
	Minimum	Maximum	Mean	Standard Deviation	Percent
Limited knowledge of soybean production	1	33	33	18.95	25.38
Occurrence of pest infestation and diseases	3	52	28	17.67	40.00
High cost of production	1	100	65	24.74	76.92
Lack of quality seed	0	51	65	19.79	39.23
Lack of labor	1	23	23	15.55	17.69
Natural crisis or calamity	1	31	31	21.21	23.85
Lack of improved planting materials	0	45	65	14.12	34.61
Inadequate storage facilities	1	33	33	22.62	25.38
Post-harvest loses	1	42	53.5	28.69	32.31
Low yield	1	92	65	38.18	70.77
Planting advice	0	5	2.3	3.50	3.85
Low price	1	94	24	19	72.30

The source of seeds planted was mainly from the market for the first season and then 39.23% lack quality seed in soybean planting. Some farmers planted soybean by broadcasting and other predominantly used row spacing. Almost all farmers, 63.84%, planted manually using the hand hoe and only few used machines for planting. This finding corroborates with a report that shortage of labor is a major problem of agricultural production in Cambodia [47], especially at the peak periods of labor demand (during land preparation, planting, weeding, and harvesting) due to the increasing migration of youths from rural to urban area as well as labor demand from other countries. In contrast in other countries such as Brazil, majority the crop is machine planting which contributed to rapid expansion in soybean production [48].

Based on the results of the study, there were multiple challenges and problems facing soybean farmers (Table 6). Fluctuation in market price and high commission charges are major constraints at marketing level. High cost of pesticide and seeds are the major constraints at economic level, which lead to high cost of production for 76.92%. Other constraints include lack of grading and packaging, payment is not made quickly and high cost of transportation which is inadequate storage facilities accounts for 34.61%. Climatic conditions, primarily temperature stress, erratic behavior of rainfall and drought affect growth and yield of soybean [9,49–53]. Environmental factors influence yield are major factors impacting yield and its stability [53,54]. Prior to the rain, many reports were coming in with seed moisture content was around 14–16%. With the prolonged rainfall, this pod saturation allowed soybean to keep increasing in moisture to the points where soybean began to swell and split the pods open [55]. Mandić et al. [56] stated that in soybean grain yield depends on the amount of rainfall from June to September when soybean plants are in the grain filling stage.

Proper germination of seedlings is assured when planted on well-prepared farmland, which can be done mechanically or manually which planting advice could play a fundamental role [57]. Improved seed bought from certified seed dealers are needed to achieve better germination of soybean on farm, as they are free from diseases and infestations which the result shows as 40.00% from occurrence of pest infestation and diseases. Grau et al. [10] reported that soybean plant health is a critical component of profitable soybean production, and that plant pathogens are an important group of disease organisms that affect soybean growth and will eventually result in poor yield. The majority of the study farmers faced with insect pests in soybean that are defoliators and pod feeders, which reduce soybean yield. In a similar research in India showed low market price, market fluctuations, and lack of knowledge about how to manage pests and diseases as constraints to soybean production [58].

The results showed that domestic soybean seeds are considered by processing in local community to be of poor quality; this leads to low demand by companies and therefore contributes to low price with the result of 72.30%. Fluctuation in market price is a major constraint at market level that leads to low prices and reduces the income of farmers every year [59]. The price of soybean was lower than other crops; this could be a disincentive for farmers to increase soybean production.

Low income and high expenditure influence the profit margin from production which can adversely influence farmers' production decision in soybean production [10]. Given that manual labor is a primary production method in Cambodia, understanding the nature of labor is important. For example, farmers would draw on communal labor and pay for it by participating in communal labor themselves as well as providing meals for the participants who are often neighbors. Labor is used during the production process and in the harvesting and post-harvest activities. Low yields could discourage potential farmers from cultivating soybean; this is supported by the result that shows that 70.77% of farmers are faced with the problem of low yield and their perception of low yield (Table 6).

Selection to plant a particular crop is complex and depend on multiple decision making factors that include descriptive variables such as agronomic characteristics, soil and climate farmers' education, farming experience, and non-agricultural income all positively influenced crop diversification [59–61]. Other factors also include crop characteristics, yields, resistance to pests/drought, cycle period, and maturity dates [59–61]. In addition, factors such land use, soil degradation and soil fertility also play a significant role in farmer decision making on selection of crops [62].

High cost of farm input, or even unavailability was another key problem (Table 6). This is in line with the finding that the adoption of many improved packages of technology has been compromised by the lack of availability of other complimentary farm inputs [11,63,64].

4. Summary and Conclusions

The findings of this study highlighted that there were many factors that were limiting soybean production technology among sampled households. Despite government promotion of the use of modern inputs such as new and improved seed varieties, fertilizers, and pesticides, farm productivity remains low. The collective impact of these is the low level of soybean yield per hectare in the study area. Moreover, most of the farmers do not have enough credit to access for their farm production, even though they have the bank in the town, but the interest rates are very high. Low production of soybean was caused by the soil fertility degradation; they do not use organic fertilizer or added chemical fertilizer lower than the crop nutrient requirement. Seeds used in the production were unidentified, they just followed their neighbor from one season to other seasons. There was no agricultural extension or NGOs training them how to grow soybean such as seed selection for the next season, fertilizer application, seed rate, and how to control pest. Rains during harvesting were reported in the area by some respondents which caused shattering and hence resulted in yield losses. Rain during harvesting not only reduces seed quality but also increases the shattering losses. Lack of proper price for the soybean grain is a challenge since there was no procurement system found in the area to purchase farmer produce at reason prices. Shortage of farm labor was also a major problem of soybean production, even though the majority of the respondents were married with a large household size.

5. Suggestions and Potential Opportunities

Based on the results of the study, the following suggestions were formulated to improve soybean production in Koun Mom district, Ratanakiri province, Cambodia. For increased soybean cultivation in the country, besides attractive output prices, improved technological package should be extended to the soybean growers. Evaluation of soybean suitability should be conducted for the farmer to adopt.

Training and re-tooling for extension workers in Ratanakiri province should be done to effectively transfer improved soybean technologies to farmer. Availability of seeds and other crucial inputs are very vital if the speed of adoption of the technology is to be improved. Development of new formal and informal systems of seed delivery programs such as seed multiplication projects and commercial outlets need to be explored. This may be through recruiting and training more extension workers to increase farmers' access to information. The focus should be on enabling soybean farmers' access to the right and timely information concerning input usage as well as market information. This will also enable soybean farmers to make informed decisions during purchase of inputs and output marketing.

Further evaluations need to be extended to examine consumer preferences for soybean genotypes in terms of protein, taste, and palatability. This might require involvement of multiple stakeholders such as processors, traders, and consumers. Another gap that has not been fully explored is soybean marketing linkages. Finally, this research recommends that studies should be done to understand how soybean as a legume could influence profitability of follower cereals crop (such as rice) as a rotation or in cropping system, and the integration of the successful soybean conservation agriculture production systems developed and implemented in Battambang province to Ratanakiri province.

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