Impact of soybean rust and resistant cultivars on the supply and demand of soybean in the global market

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Abstract

Soybean rust (SBR) is one of the most damaging fungal diseases that has threatened soybean production worldwide. In Brazil, which is the world's top soybean exporting country, SBR resistant cultivars have been developed to prevent serious losses in soybean production. To evaluate the effect of SBR on soybean production in Brazil and the impact on the global soybean market, we constructed a model for supply and demand of soybean for Brazil, the U.S., Argentina, China, EU-28 and the rest of the world based on functions that include yield, area, exports, imports, stock changes, demands (food, feed, processed products) and price linkage. Three scenarios (no loss in production due to SBR, serious production loss due to ineffective fungicide, and adoption of SBR resistant cultivars) were set and the effect of SBR and the impact of SBR resistant cultivars on soybean production and the global soybean market were estimated. Our simulation results suggest the possibility of an increase in the world price of soybean if the use fungicide is ineffective in SBR control and soybean production is seriously damaged. Adoption of resistant cultivars can alleviate the loss in soybean production due to SBR and also reduce the cost for fungicide application. Therefore, adopting SBR resistant cultivars in soybean production is necessary to maintain a stable global supply of soybean.

Keywords: adoption of resistant cultivars, fungicide application, production loss, saving costs

1 Introduction

Soybean rust (SBR) caused by *Phakopsora pachyrhizi* has significantly affected soybean production with a reported yield loss of over 80% (Yorinori et al. 2005). The disease was first detected in 2000/2001 crop season in Brazil, and the situation has worsened because the disease was novel and fungicide application has been ineffective, thereby resulting in 8.49% loss of soybean production in 2003/2004 crop season (Godoy et al. 2016). The economic losses in soybean production due to SBR occurrence was estimated at about USD1.22 billion and the fungicide cost was USD2.08 billion. In 2004, the Anti-Rust Consortium was established to control SBR. Several strategies such as implementation of soybean-free period, application of fungicide, and cultivation of SBR resistant cultivars have been recommended to manage the disease in Brazil (Consórcio Antiferrugem). Among these strategies, the main soybean producing regions in Brazil adopted the soybean-free period and application fungicide resulting in reduction of loss in soybean production (Godoy et al. 2016). However, fungicide application has gradually became ineffective year after year due to the appearance of fungicide resistant races of soybean rust (Godoy et al. 2016). Thus, soybean cultivars resistant to SBR have been developed. As of 2017, five SBR resistant cultivars have been registered in the Ministry of Agriculture, Livestock and Food Supply (MAPA) of Brazil. However, these resistant cultivars represent only 0.44% of all registered soybean cultivars grown throughout the country and are not yet popular and commonly adopted by farmers for cultivation (Childs et al. 2017).

In 2018, Brazil produced 122 million metric tons and exported 78.5 million metric tons of soybean, ranking 2nd among the top soybean producing countries and 1st among the top soybean exporting countries (USDA PS&D). The three major soybean producing countries, namely, Brazil, the U.S., and Argentina export 88.6% of soybean supply worldwide. Soybean is mainly utilized as processed products all over the world. After soybean oil is extracted, the rest is used as feed of livestock. Soybean oil is consumed as food and biofuels. As a consequence of global warming, the demand for renewable energy such as biodiesel is increasing. The demand for soybean oil and feed of livestock is also increasing especially in China and EU-28 with shares of 57.5% and 10.4%, respectively as of 2018 (USDA PS&D). Recently, there is a shift in balance among exporting and importing countries. Brazil is surpassing the U.S. and soybean export from Brazil to China is increasing due the demands for oil and feed in China (FAPRI 2018).

If the production loss of soybean in Brazil is incurred due to SBR, then soybean export will also decrease which will also affect the global soybean market. The soybean production on the global soybean market has been studied econometrically (Huyse 1983; Meyers et al. 1986; 1991; Koizumi and Ohga 2008; Robinson et al. 2015). However, the effect of SBR was not considered in these studies because SBR has emerged in Brazil just recently. Therefore, we investigated the effect of SBR and the impact of SBR resistant cultivars on soybean production and the global soybean market. For this purpose, we constructed a global supply and demand model for soybean in Brazil, the U.S., Argentina,

China, EU-28, and rest of the world in three scenarios: (1) a scenario where SBR did not cause damage to soybean production, (2) a scenario where fungicide becomes ineffective causing extensive loss in soybean production, and (3) a scenario where SBR resistant cultivars of soybean were adopted for cultivation.

2 Model

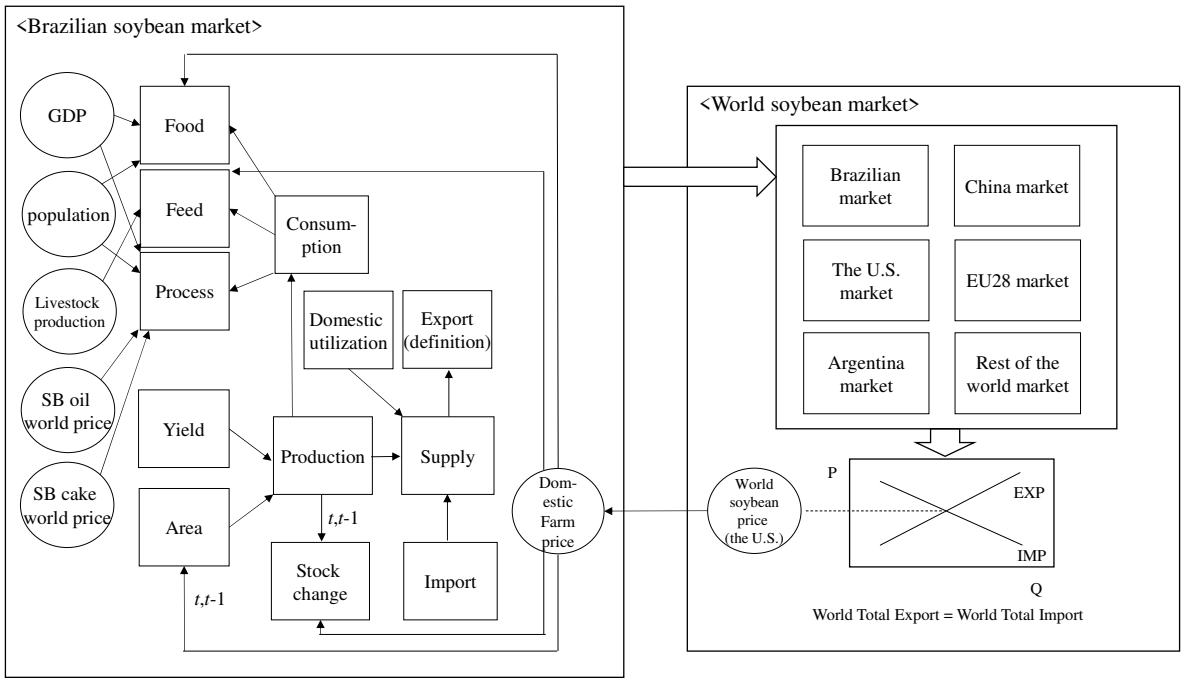

Fig. 1 Flowchart of world soybean supply and demand model.

We constructed a model of the world soybean supply and demand (Fig. 1). To evaluate SBR and SBR resistant cultivars on soybean production and the global soybean market, we used the global supply and demand model for soybean based on the models of Koizumi and Ohga (2008) and Hung et al. (2018) with some modifications. Our model consists of 48 functions and 7 identities. We estimated soybean production from the functions for yield and area harvested.

Soybean supply is influenced by production, domestic utility, export, import, stock change, domestic farm price, and world price of soybean. On the other hand, soybean demand is influenced by process, livestock production, domestic farm price, world prices of soybean oil and cake, population, gross domestic production, and consumer price index. The domestic farm price is linked to the world prices of soybean oil and cake and affects the supply in the following year. World price of soybean is determined when the world sum of exports and imports are in equilibrium. Exchange rate, world prices of soybean oil and cake, imports in Brazil, the U.S., and Argentina, exports in China, EU-28, and rest of the world, population, and gross domestic products are exogenous variables.

3 Outlook

To evaluate the effect of SBR and SBR resistant cultivars on soybean production, we set up three scenarios. The base scenario comprises maintaining the current situation. Scenario 1 assumes a non-occurrence of SBR. Scenario 2 assumes the occurrence of SBR and fungicide application could not control the damage to soybean production. Scenario 3 assumes the adoption of soybean cultivars resistant to SBR. In each scenario, we estimated the equilibrium world price of soybean.

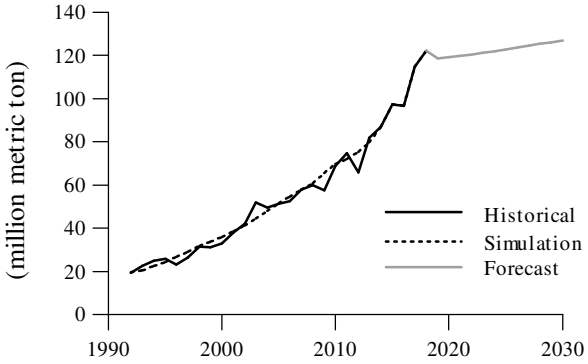

Fig. 2 Soybean production in Brazil.

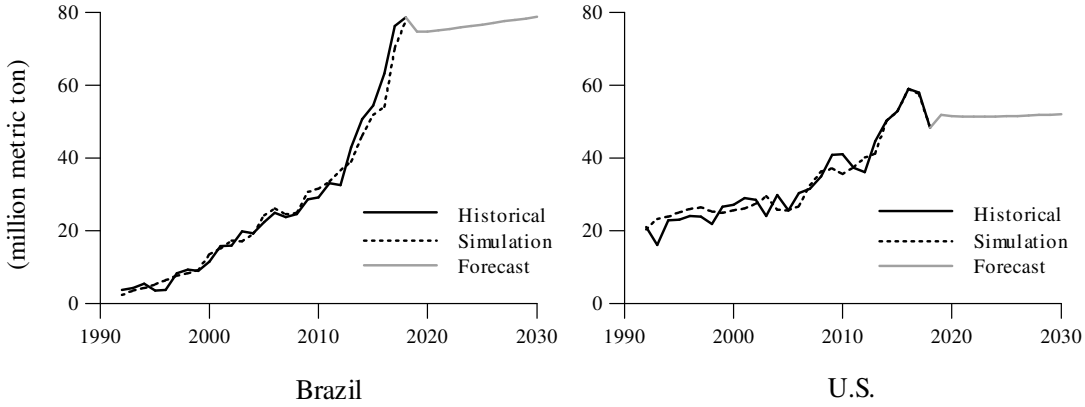

Fig. 3 Soybean export in Brazil and the U.S.

World soybean production is estimated to increase at an average rate of 0.32% annually from 2019 to 2030 and the total production will be 347 million metric tons in 2030. In Brazil, an average annual increase of 0.6% in soybean production is estimated with a total production of 127 million metric tons in 2030 (Fig. 2). The harvested area is also expected to expand (USDA FAS 2018a) with an estimated annual increase rate of 0.82%. On the other hand, our model shows that soybean production in the U.S. will not increase. As a result, Brazil will surpass the U.S. and will become the world's largest producer of soybean from 2022.

Figure 3 shows soybean export in Brazil and the U.S. Export of soybean in Brazil is estimated to increase at an average of 0.49% annually with a total of 78.7 million metric tons in 2030.

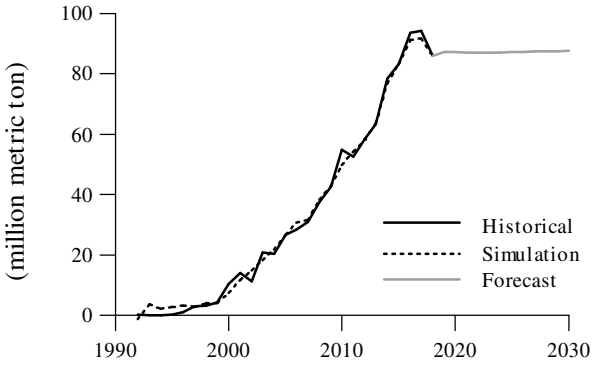

Fig. 4 Soybean import in China.

However, soybean export in the U.S. will not increase with a total of 52.0 million metric tons in 2030. This outlook is based on the assumption that the trade friction between the U.S. and China would continue. Soybean import in China is estimated to total 86.9 and 87.2 million metric tons in 2019 and 2030, respectively (Fig. 4). World price of soybean is estimated to be USD353.7/ton on average throughout 2030 (Fig. 5). Since the domestic farm price of soybean in Brazil is linked to the world price, the estimated average domestic price is USD267.4/metric ton in the same period.

In scenario 1, the average annual increase in soybean production is estimated to be 1.13% from 2019 to 2030 (Fig. 6). When soybean production increases at this rate, soybean export will increase to 0.91%, thus, world price and domestic farm price of soybean will decrease to 2.86% and 3.56%, respectively. In scenario 2, soybean export will decrease from 74.3 million metric tons in 2019 to 72.9 million metric tons in 2030 with the soybean production loss, thus, world price and domestic farm price of soybean will increase to USD422.8/ton (Fig. 7) and USD331.8/ton, respectively in 2030. When the world price of soybean increases, exporting countries tend to expand their exports but importing countries tend to reduce their imports. As a consequence, exporting countries could limit their exports. This situation would create economic crisis to countries such as Brazil and Argentina, where the amount of export is higher than that of domestic demand. In Brazil, soybean production is pursued as an agribusiness and only soybean is cultivated in most farms in one crop season. Many diseases like SBR is linked to the genetic uniformity and monoculture which makes soybean production easily vulnerable to diseases (Altieri and Pengue 2006).

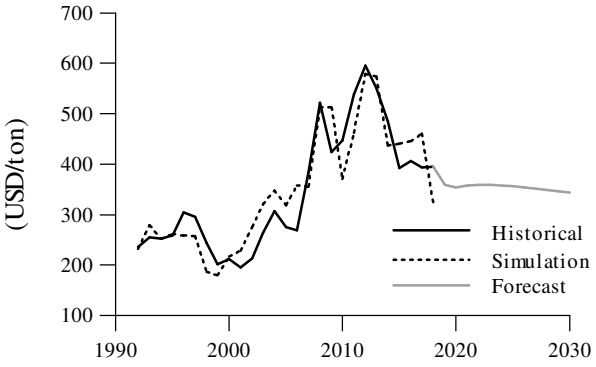

Fig. 5 World price of soybean.

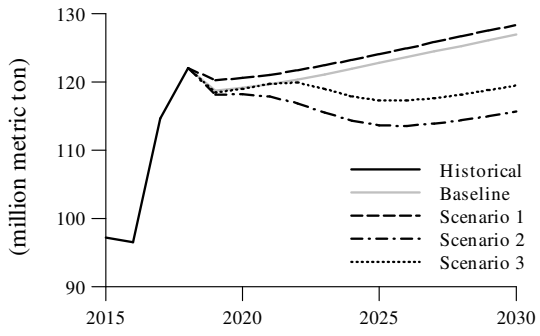

Fig. 6 Forecast of soybean production in Brazil.

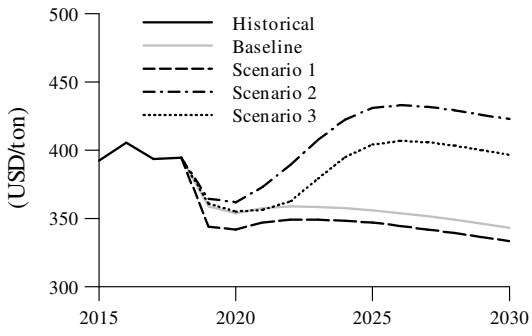

Fig. 7 Forecast of world price of soybean.

Table 1 Parameters for estimation of cost saving in using SBR resistant cultivars.

Area harvested	38.5	million ha
Area harvested for SBR resistant cultivar (a)	23.9	million ha
Area harvested for conventional cultivars (b)	15.2	million ha
Cost of fungicide application in (a)*	1.20	billion USD
Cost of fungicide application in (b)*	1.52	billion USD
Total cost of fungicide application in scenario 3	2.71	billion USD
Total cost of fungicide application in scenario 2	3.85	billion USD
Cost saving (scenario 3 – scenario 2)	1.14	billion USD

* Number of times of fungicide application was two in resistant cultivars and four in conventional cultivars (Dorneles et al. 2019). Fungicide cost was assumed to be 25 USD/hectare/spray (Godoy et al. 2016).

With global warming, the climate conditions could become favorable to growth of SBR and the fungicides could become ineffective resulting in the occurrence of SBR epidemic as assumed in scenario 2.

With the adoption of SBR resistant cultivars in scenario 3, soybean production is estimated to recover 3.32% and exports of soybean will increase by 2.75% in 2030 as compared to scenario 2. In scenario 3, world price of soybean is estimated to be USD396.5/ton whereas the domestic farm price is estimated to be USD307.4/ton. Adoption of SBR resistant cultivars also reduced the number of fungicide application (Dorneles et al. 2019). In terms of the cost for application of fungicide, SBR resistant cultivars could reduce production cost by USD1.14 billion in one year (Table 1). Since the gross domestic production in Brazil is USD1.77 billion in 2015 (FAOSTAT), adopting SBR resistant cultivars could contribute in increasing the income of farmers. Large-scale and immediate adoption of SBR resistant cultivars is recommended for sustainable soybean production recover that would eventually benefit of local farmers.

4 Conclusions

Soybean production in Brazil is facing a serious threat due to SRB which could have serious repercussions in the supply and demand of soybean in the global market. If the current situation continues, our model estimated that in 2030 Brazil will produce 127 million metric tons of soybean and will export 78.7 million metric tons of soybean. If fungicide becomes ineffective and soybean production decreases, production and soybean export are estimated to be 116 and 72.9 million metric tons, respectively. A significant reduction of soybean production in Brazil would lead to reduction of soybean in the world market that would result in an increase in the world price of soybean and probable confusion in the global soybean market. Adopting SBR resistant cultivars would allow not only the recovery of soybean production in Brazil but would also reduce the cost in using fungicides to about half and be able to recover the soybean production in Brazil. Thus, adopting SBR cultivars is indispensable for sustainable soybean production in Brazil and maintenance of a stable global soybean supply.

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