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A simple procedure to reduce production risk in vegetables double cropping: An evidence from Jordan

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Abstract

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Determination of optimum combination of cropping area of two or more crops to be produced is crucial issue to reduce production risks. This study investigated a simple optimization procedure to minimize production risks. The procedure concentrated on making the optimum use of land in double cropping of tomatoes and cucumber. The analysis was carried out using eleven combinations of cultivated land area ranging from 0% to 100% for each of the two crops. The study utilized data related to cultivated areas, quantities of production and wholesale market prices of tomato and cucumber crops for a period of 10 years (2008-2017). The data were retrieved and downloaded from the website of the Jordanian Department of Statistics. The results of the study suggest that double cropping of tomatoes and cucumber in Jordan is a useful cultivation system in reducing production risks by growing 30% of the area with tomatoes and 70% of the area with cucumber. The study recommended that agricultural extension activities should be directed to encourage farmers to benefit from simple land use optimization procedures in their double cropping activities for best land resource allocation such as the one adopted in this study.

Keywords: Jordan; land use; vegetables; optimization; coefficient of variation; double cropping

Introduction

Production risks are any uncertain production related activities or events. Production risks are related to the possibility that output levels will be lower than projected. Reductions to agricultural productivity can have significant impacts on farmer's food security, nutrition, income and well-being (Hertel, 2010; McDowell, 2012). Production risks can be created by the farmers or can come from outside of the operation or from the operation itself (Oatess, 2016).

According to Frentrup et al. (2010), production risk in crop arises from uncertainties regarding yields and qualities. Agricultural production risk derives from the uncertain natural growth processes of crops and livestock.

Adverse weather conditions, damage due to insect pests and diseases, unpredictable government policies, low quality of major inputs, failure of equipment and machinery and incorrect farm management decisions are the major sources of production risks. Fire, wind and other casualties are also sources of production risk (Crane et. al., 2013). Ashok et al. (2018) stated that fruit and vegetable farmers consider production risks as important source of risk.

Adopting risk management strategies can help mitigate risks before they occur (World Bank, 2016). By adopting different management practices farmers try to control or minimize these risks. According to Ullah et al. (2016) risk management strategies comprise of a variety of responses, that aim to lower the probability of an adverse event occur-

ring and/or reduce the adverse consequences if the event occurs. Diversifying, integrating, maintain flexibility in the use of farm assets and applying new technology are the main practices in this regard. Diversifying production activities through double or multiple cropping is a widely used practice to control or reduce production risks in many agricultural activities. The motivation for crop diversification is laid in the idea of higher returns and management of risk and uncertainty. Diversifying production activities by adding or changing enterprises is the core of the process of double cropping. Diversification is an effective way of reducing income variability. Effective diversification occurs when low income from one enterprise is offset by satisfactory or high incomes from other enterprises (Crane et al., 2013). With diversification, choosing low-risk enterprises can also help reduce overall production risk. However, the need is urgent to conduct in-depth studies in order to develop agriculture production risk management framework to identify potential threats and to define the strategy for eliminating or minimizing the impact of these risks (Abu Bakar & Rabihah, 2019).

The principal contribution of this paper is drawing of attention towards some neglected aspects to benefit from crops diversification in reducing production risks through double cropping of two main vegetables in Jordan. The expected result is optimum utilization of one of the main agricultural resources which is land.

Double Cropping

To help justify the high input cost, farmers oftentimes choose to double crop. This practice can provide a significant amount of additional income. Borchers et al. (2014) considered double cropping as one of the most important and widely used practice of a set of four main multi-cropping practices (cover cropping, integrated crop-livestock systems, woodland-based systems and double cropping). Importance of double cropping lies in the fact that it more clearly intensifies production than other multi-cropping practices do. As Borchers et al. (2014) states, double cropping involves the harvest of two crops from the same field in a given period of time. It also involves intensifying the use of existing cropland and potentially increases the economic returns. Notable economic and environmental benefits motivate the recent interest in double cropping (Searchinger et al., 2013; Siebert et al., 2010). Due to greater timing flexibility and decreased inputs, improved profitability of double cropping practice was recorded (National Institute of Food and Agriculture or NIFA, 2013).

Double cropping also aid in spreading fixed costs over a larger volume of output Lower average fixed costs and revenues from the second crop could enhance net income. By providing an additional source of cash double cropping could improve profitability and cash flow (Burton et al., 1996). Another important environmental and economic benefit offered by double cropping is that it can reduce fertilizer requirements (Heggenstaller et al., 2008). Due to spreading of fixed costs over more production, increased returns is a major economic benefit from double cropping by selling a second commodity or crop (Beuerlein, 2001).

Among many agricultural activities, due to its rapid perishable nature, short supply period or its inelastic demand nature vegetable production is a risky farming activity (Hardwood et al., 1999). Most of vegetable farms in Jordan are individual family farms, often with insufficient awareness of the importance of farm production and business planning. The decisions regarding production are most frequently made intuitively based on their experiences. Decision support systems and tools concerning optimum use of different agricultural inputs (mainly land in case of Jordan) should be recommended and developed by researchers. There is a need to provide vegetable producers with such tools to help them in managing production risks.

Vegetables Sector in Jordan

In Jordan vegetables are grown on mixed farms, which are the most common type of farm in the country. Agricultural diversification in Jordan is highly intensified towards fruits and vegetables production. In this country as well as in most developing countries, cost of vegetable production poses a challenge to expected profits because vegetable production considered being a highly risky farming enterprise either because of its rapid perishable nature, short supply period or its inelastic demand nature (Kimura et al., 2010).

According to the records of Jordan investment Commission (JIC), from 2015 up to September 2017 investment into Jordan's agriculture sector equaled a cumulative of approximately US$ 250 million. The agricultural sector in Jordan is with relatively small contribution of 3% – 4% to the country's Gross Domestic Product (GDP), equaling US$ 1.39 billion whereas 40% of that agricultural GDP is generated by crop production. The Jordanian agriculture exports represented approximately 18% of Jordan's exports (or US$ 6.2 billion) in 2016. However, when taking into account all related chain activities the additional (indirect) contribution of agriculture to the GDP is 26 to 28%. The sector is considered as a source of income for about 80 thousand Jordanian families (Ministry of Agriculture or MOA, 2017).

Jordan is self-sufficient in a number of vegetables. Over half of the Jordan Valley (the food basket of Jordan) arable

lands is used for vegetable production. The size of the Jordan Valley is about 760 000 dunums (equal to 76 000 ha), of which 430 000 dunums (equal to 43000 ha) are in use for agriculture (around 15% of the total area in Jordan with crops). Total area of crops is around 2.75 million dunums (275 000 ha), of which 1.35 million dunums (135 000 ha) fruit and vegetables of which around 90 000 dunums are vegetables greenhouses.

The main vegetables produced in Jordan are tomato, eggplant, cucumber, potato, cabbage, squash, cauliflower, hot pepper, sweet pepper, broad beans, string beans, peas, Jews mallow, water melon and onion. In terms of output, tomato is the leading crop, followed by cucumber. This is the main reason to consider these two crops in this study. According to the records of the Jordanian Department of Statistics (DOS) in 2017, total area used for tomato production is 121944.8 Dunums (1 dunum = 0.1 ha) producing around 690478 Metric Tons, and total area used for cucumber production is 16541.50 Dunums producing around 190847 Metric Tons. Figures 1-6 show trends in cultivated areas, production and wholesale market prices of tomato and cucumber respectively, during a period of 10 years (2008–2017) in Jordan.

Materials and Methods

In crop production, planning optimization is commonly used approach. This approach is used to achieve optimal resource allocation given the changing conditions that farms face (Ivana et al., 2013). A simple optimization procedure was adopted in this study to determine the optimum cropping area combination to produce two of the most important cash crops in Jordan (Tomato and Cucumber).

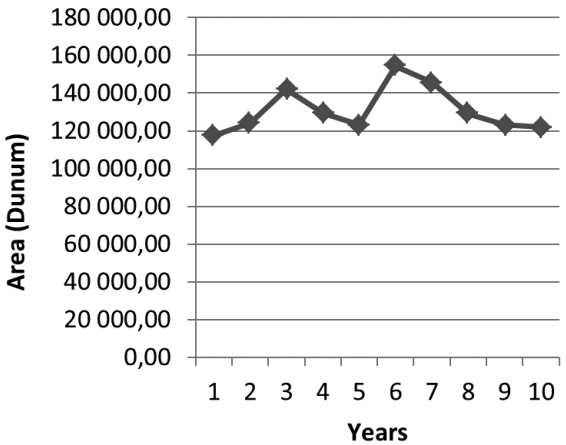

Fig. 1. Cultivated areas of tomato in Jordan (2008–2017)

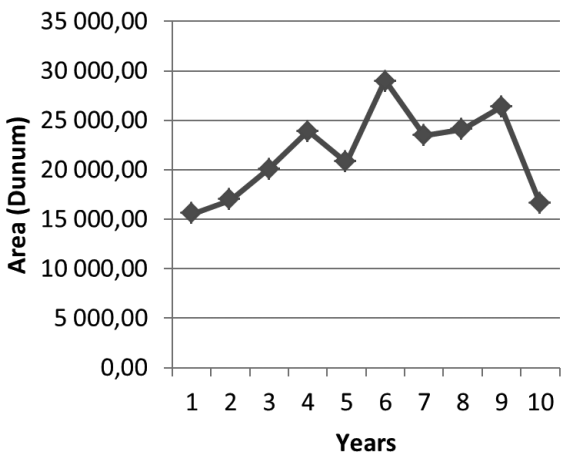

Fig. 2. Cultivated areas of cucumber in Jordan (2008–2017)

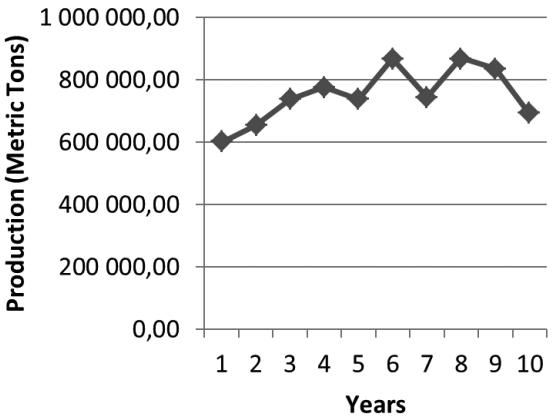

Fig. 3. Production of tomato in Jordan (2008–2017)

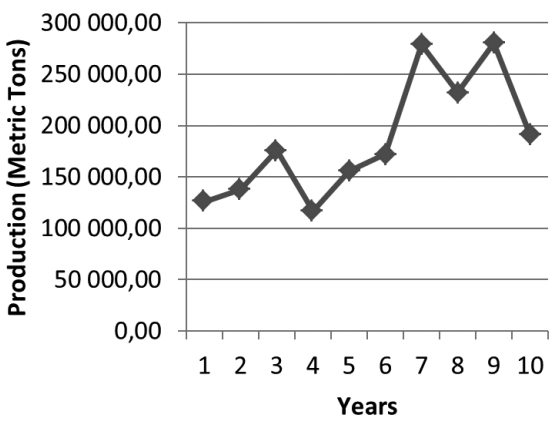

Fig. 4. Production of cucumber in Jordan (2008–2017)

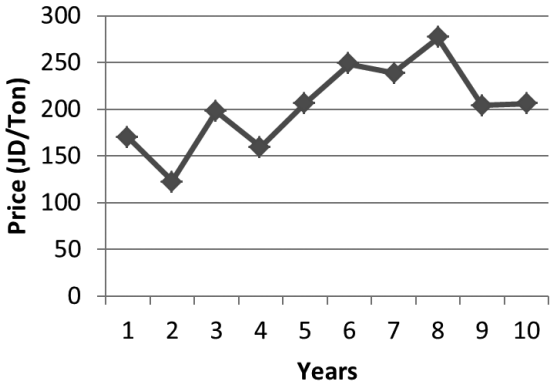

Fig. 5. Price of tomato in Jordan (2008–2017)

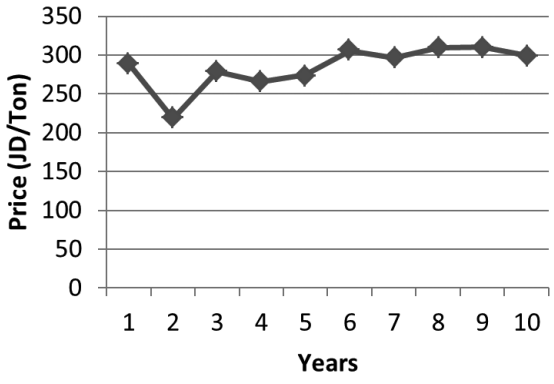

Fig. 6. Price of cucumber in Jordan (2008–2017)

Table 2. Returns from tomato and cucumber in Jordan (2008–2017)

Tomato		Cucumber	
Year	Return (JDs)	Year	Return (JDs)
2008	102 177 238	2008	36 417 567.84
2009	80 414 257	2009	30 069 530.40
2010	145 830 344	2010	49 083 552.98
2011	123 984 572	2011	31 055 242.95
2012	152 222 346	2012	42 775 110.04
2013	215 546 323	2013	52 667 188.23
2014	177 587 553	2014	82 589 032.00
2015	240 298 613	2015	71 775 168.92
2016	171 069 461	2016	86 849 073.00
2017	142 307 516	2017	57 082 337.70
Average	155 143 822.22	2008	36 417 567.84

Source: Prepared by the researchers based on DOS records (2017)

Data source

This study is based on published sources of secondary data. Since the scope of the study is confined to tomato and cucumber, data related to cultivated areas (dunums), quantities of production (metric tons) and wholesale market prices (Jordan Dinar or JD/ton) of these two crops were retrieved and downloaded from the website of the Jordanian Department of Statistics (http://www.dos.gov.jo) that provides free access to many agricultural data sources. 1 JD equal to 0.71 USD. The data covered a period of 10 years (2008–2017). Figures 1 to 6 above presented the related data. Table 1 below shows averages of cropping areas, production quantities and market prices for tomato and cucumber during the investigated period, and Table 2 shows returns from the two crops during the same period.

Table. 1 Cropping areas, production and market prices for tomato and cucumber in Jordan (2008–2017)

Year	Tomato			Cucumber		
	Area (Dunum: 1 Dunum = 0.1 ha)	Production (Metric ton)	Price (JD/ton)	Area (Dunum)	Production (Metric ton)	Price (JD/ton)
2008	117 522.60	600 336.30	170.2	15 530.70	125 925.20	289.2
2009	123 943.70	654 306.40	122.9	16 926.00	137 681.00	218.4
2010	141 886.70	737 261.60	197.8	20 120.40	176 179.30	278.6
2011	129 535.90	777 820.40	159.4	23 952.50	116 968.90	265.5
2012	123 445.20	738 226.70	206.2	20 764.90	155 942.80	274.3
2013	154 337.80	869 138.40	248.0	29 033.90	172 283.90	305.7
2014	145 640.80	744 601.90	238.5	23 427.10	279 017.00	296.0
2015	128 871.30	870 016.70	276.2	24 101.90	231 981.80	309.4
2016	123 356.80	837 344.40	204.3	26 325.70	280 158.30	310.0
2017	121 944.80	690 478.00	206.1	16 541.50	190 847.00	299.1
Average	131 048.56	751 953.08	202.96	21 672.46	186 698.52	284.62

Source: DOS records (2017)

Empirical framework

The adopted statistical procedure in this study is simple and not complicated. The procedure could be used easily by farmers or decision makers to make optimum use of land in order to reduce production risk. The decision rule in determining the optimum land area for growing each of the two crops is based on the value of the coefficient of variation (CV) of the expected returns from the two crops. The CV with two different cropping area combinations was calculated. The CV was determined by dividing the standard deviation of the returns from the two crops (S_{AB}) on the average of the expected returns from the two crops using different cropping area combinations ($é_{AB}$). Cropping area combinations are shown in Table 3.

As a rule, the lowest CV value is with the least level of risk and the corresponding cropping area combination is the optimal one to be adopted.

The statistical procedures were as follows:

$$S_{AB} = \sqrt{S^2_{AB}}$$

$$S^2_{AB} = a^2S^2_A + (1 - a)^2S^2_B + 2r_{AB}\,a(1 - a)\,S_AS_B$$

$$é_{AB} = a\,é_A + (1 - a)\,é_B$$

$$CV = S_{AB} \div é_{AB}$$

where, A: Tomato crop

B: Cucumber crop

S^2_{AB}: Variance in returns of tomato and cucumber combination

S_{AB}: Standard deviation in returns of tomato and cucumber combination

a: Area used to grow tomato (%)

1 – a: Area used to grow cucumber (%)

S^2_A: Variance in returns of tomato (2.36E+15)

S^2_B: Variance in returns of cucumber (4.2E+14)

S_A: Standard deviation in returns from tomato (48623337)

S_B: Standard deviation in returns from cucumber (20499473)

r_{AB}: Correlation coefficient between tomato and cucumber (-0.6768061)

$é_A$: The expected average return for tomato (155,143,822.22)

$é_B$: The expected average return for cucumber (54,036,380.41)

$é_{AB}$: The expected average return for the two crops

Results and Discussion

Table 4 below shows the results of the calculations related to the investigated crops based on the data presented in tables 1 to 4.

Based on the value of the coefficient of variation between the returns from both crops, the results presented in Table 4 show that among several combinations of tomato and cucumber cultivated areas, the optimal combination that minimizes production risks when using double cropping of tomatoes and cucumber is to grow 30% of the

Table 3. Cropping land area combinations for tomato and cucumber

Crop	Ratio (%)										
A (Tomato)	0	10	20	30	40	50	60	70	80	90	100
B (Cucumber)	100	90	80	70	60	50	40	30	20	10	0

Source: Suggested by the researchers

Table 4. Results of calculations

Cropping Area		Expected Average Returns ($é_{AB}$)	Standard Deviation (S_{AB})	Coefficient of Variation (CV)
A (%)	B (%)			
0	100	54 036 380	20 499 473	0.379364288
10	90	64 147 125	17 415 869	0.271498820
20	80	74 257 869	15 986 804	0.215287673
30	70	84 368 613	16 644 057	0.197277831
40	60	94 479 357	19 174 272	0.202946678
50	50	1.05E+08	22 966 543	0.219586198
60	40	1.15E+08	27 503 687	0.239786262
70	30	1.3E+08	32 474 988	0.249394701
80	20	1.35E+08	37 709 126	0.279487651
90	10	1.45E+08	43 110 473	0.297245798
100	0	1.55E+08	48 623 337	0.313408142

Source: Calculated by the researchers

area with tomatoes and 70% of the area with cucumber. The value of the coefficient of variation between the returns from both crops corresponding to this ratio is almost 0.197 which is the lowest value among all CV values.

Conclusions and Recommendations

As a result of variable economic and biophysical environment in which farming operates agricultural activities are subject to a wide range of risks. Among the many risks agricultural production or yield risk is the most important (Chuku and Okoye, 2009). To help justify the risks in producing crops, farmers oftentimes choose to double crop. Diversifying production activities by adding enterprises is the base of the process of double cropping. Double cropping aims to make optimum use of land. This practice can provide a significant amount of additional income for the farm if a good farm management plan is in place. Stabilizing net farm income is one of the most important results obtained from using double cropping especially if growing season length and other factors necessary for crop production are adequate.

In Jordan, most farmers grow tomatoes and cucumber in practicing double cropping. Among several combinations of tomato and cucumber cultivated areas, the results of the present study revealed that the optimal combination is to grow 30% of the area with tomatoes and 70% of the area with cucumber. The results of the study suggest that double cropping of tomatoes and cucumber in Jordan is a useful cultivation system in reducing production risks. It is highly recommended to consider double cropping with optimum land use to grow more than one crop in the same area. The procedure followed in this study is a useful and simple one to determine the optimum combination of the cultivating area in double cropping cultivation system. Agricultural extension activities should be directed to encourage farmers to benefit from such procedure in their double cropping activities for best land resource allocation.

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