The Impact of Barley Varietal Technology on Factor Demands Under Rainfed Condition In Iraq

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Summary

The main purpose of this study is to assess the impact of improved barley cultivar, Rihan 03, on factor demand and output supply using cross-sectional data of 495 farmers. An indirect profit function within the framework of duality theory was specified and estimated using the Ordinary Least Squares and Seemingly Unrelated Regression Estimation Procedures. Results indicate that the use of improved variety will increase the demand for seed by (16-23)%, for fertilizers by (15-22)%, for machinery by (20-29)% and for labor by (19-29)%. These results have important policy implications in that the supplies of seed, fertilizers, machinery and labor should be increased to the levels of new demand in order to increase the efficiency of barley production under rainfed conditions of Iraq. Estimated price elasticities implied that output support price policy is more effective in increasing barley production compared to subsidizing input prices, such as seed and fertilizers.

Keywords: varietal technology; duality theory; improved cultivar.

Introduction

New crop varieties, like any other new technology, may change the optimal levels of inputs used. The profitability of adopting new varieties will depend on how the demand for inputs is changed and how large is the productivity improvement is (Lin, 1994). Thus, an understanding of the effect of new varieties on input demand and productivity is crucial for better understanding of potential diffusion of the technology among farmers. Results indicate that the technical change in wheat production, for example, has been cost-saving and has not been strongly biased in either a labor-saving or a capital-saving direction (Sidhu, 1974). New technology is an important source of productivity gain in various production systems. Producers benefit from inputs or maintain the same output from reduced inputs (Griffith *et al.*, 1995).

Research activities in Iraqi National Agricultural Research System have resulted in introducing several barley improved technologies into the farming system of Iraq. With the impressive adoption rates of these technologies as it was evident from technology adoption surveys (Shideed, 1997), there is a need to quantify the impact of new technologies at the farm level. The main purpose of this study is to assess the impact of improved barley cultivar, Rihan 03, on the demand for seed, fertilizers, machines and labor. This requires the estimation of factor demand and output supply equations. The derived own-and cross-price elasticities will be used to assess implications of selected pricing policies, on barley production under rainfed conditions. Rainfed farming is a major source of barley production in Iraq. Nearly 48% of barley was produced under rainfed conditions during the last four decades.

Materials and Methods

The data was collected from a cross-sectional survey of 495 farmers in 6 districts in Ninavah Province during the Summer of 1996 (Saleem, 1998). These counties are located in the two rainfall zones designated for barley production under rainfed conditions. The rainfall zones are the moderate rainfall areas (MRA) and the limited rainfall area (LRA) of an annual rainfall of (350-450)mm and (200-350) mm, respectively. A stratified random sampling technique was used by containing farmers not overlapping with the farmers in other districts. Then, proportional allocation procedure was applied to determine the sample size for each district (Scheaffer, *et al.,* 1979). Among the sample, 210 farmers planted the improved barley cultivar, Rihan 03, and 208 farmers grew the Local Aswad cultivar. Whereas, 77 of the sample, farmers planted both improved and local cultivars. For the last group, there will be two observations for each farmer. As a result, the total number of observations in the data set is 572.

To study the impact of the improved cultivar on supply of barley and the demand for variable inputs, it is important to derive, first, the factor demand and output supply functions. For this purpose an indirect profit function within the framework of duality theory is specified. Previous studies suggest that in the study of production using farm-level data, the application of normalized restricted profit function and factor demand functions is a more reasonable and less problematic approach (Sidhu and Baanante, 1979 and 1981). Such an approach overcomes many of the problems associated with direct estimation of production and demand functions. The concept of normalized production function is more appropriate than the production function for empirical analysis of short-run production decisions, for at least two reasons (Sidhu and Baanante, 1979). First, the normalized profit function is a function only of predetermined variables and thus econometrically more appropriate for estimation. Second, the system of input demand functions and output supply function derived from the normalized restricted profit function facilitates interpretation and analysis for deriving policy implications.

Assume that barley production function for farmers of Ninavah province is specified as:

(1) $Y=f(S, F, M, N; L, E, DV_1)$

where Y is total output of barley (ton); S, F, M and N are the variable inputs of seed, fertilizer, machinery, and

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labor, respectively. L and E are fixed factors of land and education, respectively. DV_1 is the varietal dummy variable taking the value of 1 for the improved cultivar and and zero for the local variety.

For the specified production function (1) there is a correspondening normalized restricted profit function. Per farm restricted Profit π, is defined as total revenue from barley less total variable costs, and after normalization by the price of barley P is expressed as a function of the normalized prices of the variable inputs of seed, fertilizer, machinery, and labor and the quantities of the fixed inputs of land and education, following Sidhu and Buanante, 1979:

(2) $\pi^* = \pi \div P = f(Pi; L_1, E, DV_1,$
$i=S, F, M, N$

Where Pi is the normalized price of variable inputs. Demand functions for the variable factors of seed, fertilizer, machinery and labor are obtained by differentiating the normalized profit function with respect to the respective normalized input prices:

(3) $Xi^* = \partial\pi^* \div \partial Pi$, i= S, F, M, N

where Xi^* refers to the quantity of input i.

Under the assumption that the production function (1) is of Cobb-Douglas form, the estimatable equations in (2) and (3) can be specified as:

(4) $Ln\pi^* = Ln\ A + B_1 LnPs + B_2 LnPr + B_3 LnPm + B_4 LnPn + B_5 Ln\ Age + B_6 LnE + B_7 LnL + B_8 DL + B_9 DV_1$

Where, Age refers to the farmers age in years, and DL is a dummy variable to measure the impact of farm size and taking the value 1 if the farm size is greater than or equal 25 hectare and O if it is less than 25 hectares [(1)].

(5) $- P_s.\ S \div \pi^* = B + A_2\ DV_1$

(6) $- P_f.\ F \div \pi^* = S_o + S_2\ DV_1$

(7) $- P_m.\ M \div \pi^* = D_o + D_2\ DV_1$

(8) $- P_n.\ N \div \pi^* = E_o + E_2\ DV_1$

where equation (4) is the normalized restricted profit function in the logarithmic form and equations (5)-(8) are the factor share equations for seed, fertilizer, machinery, and labor. Equations (4)-(8) represent a system in which the restricted profit and factor shares are set of jointly determined variables (Sidhu and Baanante, 1979). Whereas P_s, P_f, P_m, and P_n are the prices of seed, fertilizer, machinery, and labor, respectively.

The parameters A_2, S_2, D_2, and E_2 in equations (5) -(8) are equal to their corresponding parameters in equation (4) under the assumption of profit maximization for both improved and local barley cultivars. This hypothesis of profit maximization can be tested directly by comparing this system with another one that does not assume the equality of these parameters (unconstrained model). The dummy variable, DL, is added to equation (4) to compare the economic efficiency and its components of technical efficiency and price efficiency for small farms (< 25 ha.) and large farms (≥ 25 ha.). If both small and large farms have equal efficiency parameters, the dummy variable DL will be excluded from the model.

(1) The dividing thershold is taken at 25 hectare which is the distributing unit under prevailing Iraqi land reform act, No. 117 in 1973.

To complete the specification of the model, additive error terms having zero means and finite variance are assumed for each of the five equations, (4)-(8), in the model. The covariances of the error terms of any two of the equations for the same farm may not be zero, but the covariances of the error terms of any two equations corresponding to different farms are assumed to be identically zero. This means that error terms of different equations are "contemporaneously correlated" (Kennedy, 1985). Under these assumptions, an asymptotically efficient method of estimation is the Zellner's Seemingly Unrelated Regression Estimation Procedure (SURE). Both SURE and OLS procedures are used to estimate the specified econometric model, equations (4)-(8), using previously described farm-level data.

Results and Discussion

The results of the estimated equations are presented in Table 1. Although the estimated coefficients are economi-

Table 1. Estimated Parameters for Profit Functions and Factor Demand Functions for Variable Inputs.

Functions and Variable	Estimated Parameters	OLS	SURE
Rpofit Functions			
Intercept	A	-1.997 (-7.86)**	-0.688 (-3.40)**
Ln seed price	B1	-0.339 (-0.88)	-0.416 (-1.39)
Ln fertilizer price	B2	-0.228 (-1.67)	-0.183 (-1.72)*
Ln machinery price	B3	-0.101 (-3.03)**	-0.125 (-4.85)**
Ln labor price	B4	-0.114 (-0.733)	0.123 (1.02)
Ln education	B6	-0.099 (-1.46)	-0.086 (-1.63)
Ln area	B7	0.884 (26.39)**	0.623 (23.90)**
Cultivar (dummy variable)	B9	0.522 (4.06)**	0.528 (4.49)**
SSE		803.32	918.79
D-W test		1.78	1.60
R-2		0.60	0.60
Demand function for seed			
Intercept	B0	5.557 (46.09)**	5.557 (46.17)**
Cultivar	A2	-0.259 (-1.52)	-0.259 (-1.53)
Demand function for machinery			
Intercept	S0	3.338 (37.07)**	3.338 (37.14)**
Cultivar	S2	-0.379 (-2.98)**	-0.379 (-2.98)**
Demand function for labor			
Intercept	D0	0.903 (11.89)**	0.903 (11.92)**
Cultivar	D2	-0.458 (-4.27)**	-0.458 (-4.28)**
Demand function for fertilizer			
Intercept	E0	2.904 (20.02)**	2.904 (20.06)**
Cultivar	E2	1.250 (6.10)**	1.250 (6.12)**

** Significant at 1% level, * Significant at 5% level. Numbers in parantheses refer to t-statistic.
Note: Factor demand functions refer to factors shares.

cally plausible and statistically significant, the parameters of seed price, labor price and education are not significant. For cross-sectional data, the variatation in the prices of seed and labor is limited, which is in turn reflected on their significance. Application of Hotelling Lemma to the estimated model, the negative of the partial derivative of the profit function with respect to input price gives factor demand function for that input. Similarly, the partial derivative of the normalized restricted profit function with respect to barley price gives the output supply function. The derived output supply and factor demand functions are presented in Table 2.

Table 2. Estimated Factor Demand and Output Supply Equations of Barley.

Variable	Demand Equations For				Barley Supply equation
	Seed	Fertilizer	Machinery	Labor	
Intercept	0.286	0.126	0.086	-0.085	-1.101
Seed Price	-1.416	-1.416	-1.416	-1.416	-1.416
Fertilizer Price	-0.183	-0.183	-0.183	-0.183	-0.183
Machinery Price	-0.125	-0.125	-0.125	-0.125	-0.125
Labor Price	0.123	0.123	0.123	-0.877	0.123
Output Price	1.601	1.601	1.601	1.601	1.601
Education	-0.086	-0.086	-0.086	-0.086	-0.086
Area	0.623	0.623	0.623	0.623	0.623
Cultivar	0.528	0.528	0.528	0.528	0.528

From these estimated input demand functions, it is possible to calculate the impact of improved barley cultivar on the demand for seed, fertilizer, machinery and labor. Data presented in Table (3) express the impact of Rihan 03 on the demand for variable inputs. It is clear that the use of the improved cultivar will increase the demand for seed by (15.6-23)%, for fertilizers by (15.4-21.9)% , for machinery by (20-29)% and for labor by (18.6-28.5)%. These results are consistent with the findings of previous studies in that improved technologies will increase the demands for variable inputs of production. This means that the use of the improved cultivar requires higher input levels compared to the local variety. These results have important policy implications in that the supplies of seed, fertilizers, machinery and labor should be increased to the levels of new demand in order to increase the efficiency of barley production under rainfed conditions of Iraq.

Table 3. Impact of Rihan 03 on the demand for seed, fertilizers, machinery and labor.

Input	Impact of Improved Cultivar According to (%)		
	Actual Farm Use	Estimated Model	
		OLS	SURE
Seed	6.2	15.6	23.0
Fertilizers	17.8	15.4	21.9
Machinery	14.8	20.0	29.0
Labor	14.1	18.6	28.5

Note: Impacts were estimated at the sample average levels of the variables, as follows: Average price of seed=78.0 I.D/kg. Average price of fertilizers=42.7 I.D/kg. Average price of machinery=156.9 I.D/hr. Average price of Labor= 94.8 I.D./hr. Average price of barley=72.7 ID/kg. Average years of education=8.1 Year. Average planted Area=92.7 Ha

Estimated own- and -cross-price elasticities show that barley price is the most important variable affecting resource use in barley production (Table 4). The estimated elasticities of output supply and factor demand functions of seed, fertilizers, machinery and labor with respect to barley price demonstrated elastic response (elasticity is greater than one). Meanwhile, own- price elasticities of factor demand functions were elastic, as well. Whereas, all cross-price elasticities of demand functions were less than one in absolute value and smaller than own-price elasticities by one, an cross-price elasticities were negative indicating a complementary relationship among production variable inputs.

Table 4. Estimated Own-and Cross-Price Elasticities.

Demand Variable	Barley Price	Seed Price	Fertilizer Price	Machinery Price	Labor Price	Land
	Estimated Elasticities According to SURE					
Barley Supply	0.782	-0.339	-0.228	-0.101	-0.114	0.884
Seed Demand	1.782	-1.339	-0.228	-0.101	-0.114	0.884
Fertilizer Demand	1.782	-0.339	-1.228	-0.101	-0.114	0.884
Machinery Demand	1.782	-0.339	-0.228	-1.101	-0.114	0.884
Labor Demand	1.782	-0.339	-0.228	-0.101	-1.114	0.884
	Estimated Elasticities According to SURE					
Barley Supply	0.601	-0.416	-0.183	-0.125	-0.123	0.623
Seed Demand	1.601	-1.416	-0.183	-0.125	-0.123	0.623
Fertilizer Demand	1.601	-0.416	-1.183	-0.125	-0.123	0.623
Machinery Demand	1.601	-0.416	-0.183	-1.125	-0.123	0.623
Labor Demand	1.601	-0.416	-0.183	-0.125	-0.877	0.623

These estimated price elasticities have important policy implications. They showed that output support price policy is more effective in increasing barley production compared to subsidizing input prices, such as seed and fertilizers. The combined effect of reducing the prices of both seed and fertilizers by 10% resulted in increasing barley production by 5.67%, which is less than the increase of increasing barley price by 10% estimated at 7.82%.

Similarly, the impact of output on input use was more effective than the combined effect of subsidizing seed and fertilizer prices (Table 5). This requires giving output support price policies a priority in increasing barley production in Iraq. This result is consistent with the findings of previous studies in that output support price policy is more effective in increasing the growth of agricultural production in developing countries (Sidhu and Baanante, 1979 and 1981).

In conclusion, there are two interrelated agricultural policies that directly affect production. The first one is to introduce new technologies, such as improved cultivars in order to increase yield and then total production. The other policy is pricing policies of the output and inputs which in

Table 5. Policy implications of selected pricing policies for barley production.

Type of Pricing Policy	Percentage of Impact (%)				
	Seed use	Fertilizer use	Machinery use	Labor use	Barley output
1. Reducing seed price by 10%	13.9	3.39	3.39	3.39	3.39
2. Reducing fertilizers price by 10%	2.28	12.28	2.28	2.28	2.28
3. (1) + (2)	16.18	15.67	5.67	5.67	5.67
Increasing barley price by 10%	17.82	17.82	17.82	17.82	7.82

return affect the use of variable input. The first type of these policies resulted in increasing total factor productivity by 19% compared to the productivity levels achieved under the local cultivar (Shideed and Saleem, 1998). This impact highly exceeds the effect of supporting output price or subsidizing input prices. Although support price policies affect increased output and thus input use, their effect is lower than the net technical impact of increased productivity of improved cultivar, Rihan 03. Thus, varietal barley production technologies contributed greatly to the increase of barley production in the rainfed area of Iraq under prevailing output support price and input subsidizing policies for fertilizers and other inputs. This will call for greater integration between pricing policies and activities of introducing improved technologies in order to facilitate the technology adoption by farmers.

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أثر الصنف المحسن على طلب الموارد لمحصول الشعير تحت ظروف الزراعة المطرية في العراق

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الخلاصة :

استهدف البحث دراسة أثر الصنف ريحان 3 كتقنية جديدة على الطلب على موارد الإنتاج وعرض الناتج تحت ظروف الزراعة المطرية واعتماداً على بيانات ميدانية لعينة شملت 495 مزارعاً من مُنتجي الشعير.

تم توصيف وتقرير دالة الربح غير المباشرة المعدلة ضمن إطار النظرية الثنائية (Duality theory) ومن دالة الربح غير المباشرة تم الحصول على دوال الطلب للموارد المتغيرة ودالة عرض الناتج من خلال أخذ المشتقة الجزئية الأولى لدالة الربح بالنسبة لأسعار الموارد والناتج، على التوالي.

وقد اظهرت النتائج بأن استخدام الصنف ريحان (03) يؤدي الى زيادة الطلب على البذور بنسبة (16–23)٪ وعلى الأسمدة بنسبة (15–22)٪ وعلى المكننة بنسبة (20–29)٪ وعلى العمل اليدوي بنسبة (19–28)٪. ولهذه النتائج تطبيقات هامة في مجال السياسات الزراعية تتمثل بضرورة زيادة كميات البذور والسماد والمكننة والعمل بما يتناسب ومستويات الطلب الجديدة عليها بهدف زيادة كفاءة إنتاج الشعير تحت الزراعة المطرية في العراق. وبينت المرونات إن دعم سعر الشعير خيار أكثر فاعلية للسياسة الزراعية في زيادة إنتاج الشعير مقارنة بدعم أسعار الموارد مثل البذور. وهذه النتيجة تدعم ما توصلت إليه الدراسات السابقة لصالح دعم سعر الناتج مقابل دعم أسعار الموارد لزيادة نمو الناتج الزراعي في البلدان النامية.

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