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Journal of Agronomy, Technology and Engineering Management

Article

Factors Affecting the Farmers' Decision-Making on Tractor Power Selection in Pistachio Farms: The Case of Siirt Province in Turkey

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Received: 14 May 2021; Accepted: 15 June 2021

Abstract: The selection of tractor power and agricultural equipment-machinery in agriculture is one of the most important issues in terms of mechanization planning and optimization. It is stated that the most important factors influencing the selection of tractors and agricultural machinery are land type, land size and crop production pattern. The main purpose of this study was to determine the major factors affecting tractor power selection in pistachio production farms in Siirt province in the Southeast Anatolia Region of Turkey. Study data were obtained from the 69-tractor owned pistachio farms using questionnaires during the face-to-face interviews in 2019. Descriptive statistical methods and multiple regression analysis with the least squares estimation procedure was used to determine the tractor power level and the factors affecting the selection of tractor power. Data analysis revealed that farmer age, the number of parcels, the soil structure had significant effect on the selection of tractor power as the effect of education level, the share of rented land in total farmland, and land slope were marginally significant. However, the ratio of irrigated land and pistachio acreage in total farmland and stoniness was not effective.

Keywords: agricultural mechanization; tractor power; farm size; orchards; regression

1. Introduction

The food requirement is expected to increase dramatically because of the rapid increase in the world population [1]. As a result, to ensure food security in future, more than a doubling of agricultural production is required [2]. Therefore, the agricultural mechanization, which is defined as the process of using machinery to hasten the agricultural works, accomplish the tasks on time and reduce fatigue and need for human labour in order to produce better quality goods and services, will gain importance in agricultural production in future. It is reported that many factors such as farm size, production system, duration of production process, land structure, soil types, some socio-economic and environmental factors have significantly affected the development of agricultural mechanization [3-5]. Although agricultural mechanization in the widest sense covers all hand tools, draught animals and mechanical technologies, tractor is one of the most important mechanical power because it is an important source of farm energy and power for mechanization of farm operations [6]. Similarly, many researchers {4, 7, 8] stated that agricultural mechanization is synonymous with tractorization and it is a critical input for agricultural mechanization and a major indicator for assessing level of agricultural development in any country. Tractors are not only used for field works but also for transportation and additional power applications such as drainage, irrigation, road works and canal making etc [4].

Choosing the right tractor in agricultural production, especially the right power, significantly influence the economic sustainability of agricultural operations [9]. The selection of a tractor of a certain power depends upon many factors such as the land use, the size of the land, the crop and the soil type [10]. [11] analyzed the farm tractor asset in Konya districts in terms of power distribution. They reported that the farmers mainly growing field crops in large acreages had heavy-duty tractors as the vegetable and fruit farmers preferred less powerful and usually single-axle tractors. Similarly, [12] found a strong correlation between farm size and tractor power. In agricultural production, both size and geometric structure of parcel have very significant influence on selection of the machines size and tractor power. Since the use of machines in very small size parcels is not very efficient [3], a good understanding of the factors affecting the tractor power is a prerequisite for the correct tractor selection to accomplish most of farms work. Accordingly, the purpose of this study is to evaluate the factors affecting the choice of tractor power in the pistachio growing farms.

2. Materials and Methods

This study was conducted in Siirt province, which is located in the South-Eastern region of Turkey (Fig. 1). Siirt province is located approximately between 37° 55′ 30″ North latitude and 41° 56′ 45″ East longitude with an elevation of 914 m asl. It covers an area of 562.705 ha of which 18.3% is used in agricultural production. Siirt pistachio is cultivated in approximately 24 percent of total agricultural land with an annual production of around 11,000 metric tons of pistachio nut [13].

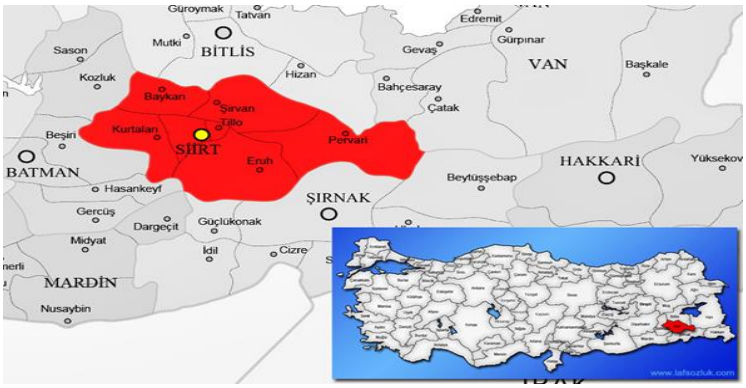

Figure 1. Map showing the survey area.

Study data were obtained through face-to-face interviews conducted with pistachio farmers who own tractor. The sampling frame covers the entire member list of the members of the Siirt province pistachio producers' association. Study villages were selected according to the records of the Provincial Directorate of Agriculture and Forestry. Sample size was calculated according to the proportional sampling Eq. (1) and (2) following [14].

$$n = \frac{N\,p\,(1-p)}{(N-1)D^2+p(1-p)}, \tag{1}$$

$$D = \frac{d}{Z_{\sigma/2}} \tag{2}$$

Where;
n = sample size
N = Population size
d = Deviation from the population mean (%10),
$Z\sigma/2$ = z value at the 90 percent confidence interval (=1,65)
p = Probability that a sampled farmer owns a tractor (it was purposively taken as 0.50 to achieve the maximum sample size)

The sample size was calculated to be 64. However, considering the possibility of excluding some questionnaires due to incomplete responses, 68 pistachio growing farms were visited and all questionnaires were evaluated.

Descriptive statistical methods and analysis of the data, multiple regression analysis with the least squares estimation procedure were used in analysis of the data. The regression model is given in Eq. 3 [15].

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k + \mathrm{e} \quad (3)$$

Where;

Y represents the dependent variable

$X_1 \ldots X_k$ represent the independent or predictor variables

α represents intercept or constant, the expected mean value of Y when all predictor variables are set to zero.

$\beta_1 \ldots \beta_k$ represent the estimated slope coefficients of the predictor variables.

k represents kth coefficient.

e represents the error term.

In regression models, categorical variables are represented by dummy variables in number one less than the number of categories [16]. In the present study, the variables showing the farmer's age and education status, and land properties such as land size, number of parcels, the slope of the land, the soil texture and the stoniness of the land are categorical variables (Table 1).

Table 1. Variables used in the regression model.

Variables	Units
Tractor power	HP
Farmer age	2: < 40; 3:40-59; 4: >=60
Farmer education level	1: non-degree, 2: Primary school, 3: Secondary school and above
Total arable land size	Decare
Number of parcels	Number
The ratio of rented land in total farmland	%
The ratio of irrigated land in total farmland	%
The ratio of pistachio acreage in total farmland	%
Land slope	1:flat land; 2: sloping land
Stoniness	1: non-stony; 2: stony
Soil texture	1: sandy; 2: loamy; 3: clayey

Accordingly, three-category variables were represented with two dummy variables in the model, as two-category ones were represented with a single dummy variable. The categories included in the regression model are evaluated based on the first category not included in the model. The coefficients of each continuous variable shows the marginal change in the dependent variable caused by a unit change in the explanatory variable when there is no change in the other variables. The classical regression models works under a number of assumptions such as: 1.) the model error term has a normal distribution, 2.) there is no correlation between the explanatory variables or there is no multicollinearity problem, 3.) the error terms are independent from each other, that is, there is no autocorrelation problem, 4.) the dependent variable values related to each independent variable have equal variance. (homoskedasticity), etc [15]. In this study, it was accepted that the tractor power in farms is a function of the continuous and categorical variables given in Table 1.

Skewness-Kurtosis test was used to test whether the error terms showed normal distribution or not. Heteroskedasticity and multicollinearity were tested with Breusch-Pagan and variance inflation factor (VIF), respectively. Since autocorrelation is a problem of time series and cross section data are used in the present study, autocorrelation test was not performed [15-19]. Data analysis was performed by using Stata SE 14.2 software [20].

3. Results and Discussion

The characteristics of surveyed farms is presented in Table 2. It was observed that most of the respondents (76.5%) were at their middle ages ranging between 40 and 60) and more than 65% of respondents had only the primary or lower secondary levels of education. Age and education status of farm owners are important for the application of modern agricultural techniques in agriculture [21].

Table 2. Characteristics of surveyed farms and percent distribution.

Variable	Percent distribution (%)	Mean	Minimum	Maximum
Farmer Age		-	-	-
10-40	13.2			
40-60	76.5			
>60	10.3			
Farmer education level		-	-	-
Non-degree	16.2			
Primary school	51.5			
Secondary school or more	32.4			
Total arable land size (ha)		7.81	0.9	46.2
<1	1.5			
1-4.9	51.5			
5-9.9	23.9			
10 and more	23.9			
Irrigated land size (ha)		0.27	0.15	0.33
Non-irrigated	73.6			
<1	16.1			
1-4.9	10.5			
5-9.9	-			
10 and more	-			
Pistachio nut land size (ha)		5.12	0.2	26.5
<1	7.4			
1-4.9	59.0			
5-9.9	19.5			
10 and more	16.4			
Number of parcels		6.59	1	63
<5	48.5			
5-10	38.3			
>10	13.3			
Land slope				
Flat land	32.4			
sloping land	67.6			
Stoniness				
Non-stony	33.8			
Stony	66.2			
Soil texture				
Sandy	14.7			
Loamy	77.9			
clayey	7.4			
Tractor Power (HP)		71.63	13	98
<15	1.5			
16-55	35.3			
56-75	13.2			
>75	42.7			

The average farm size of surveyed farms was 7.8 ha and 51.5 % of the studied farms had arable land varying between 1 and 5 ha in total. Also, more than 75% of the farm land was rainfed. It is a well known that farm size and/or the geometry of the farm structure is of great importance to achieve

high performance in farm machinery [4]. Average number of parcels per farm was 6.59. It was also found that more than half of surveyed farms had sloping and stony land. The average tractor power was 71.3 HP and the 42.7% of farms had tractors with more power than 75 HP.

Skewness-Kurtosis test revealed that the model error term had a normal distribution ($p<0.1$). Similarly, the independent variables (VIF values) indicated that there was no multi-collinearity problem, since the highest VIF value was 3.40 as the average was 2.11, remembering that VIF values below 10 can be accepted as the rule of thumb (Table 3) [16]. However, heterokedasticity is a common problem in cross-sectional data and so the robust standard errors technique was used in calculations to correct this problem [16, 17, 19]. Of all variables examined, farmer's age, the number of parcels and the soil structure were found significantly effective on tractor power, as the effects of education level, rented land ratio and land slope was marginally significant (Table 3). On the other hand, it was revealed that total farm size (ha), the ratio of irrigated land and of pistachio acreage in total farm land and stoniness had no significant effect on tractor power. When compared to the farms with sandy soils, the base category, the tractor power marginally significantly increased ($p<0.1$) in farms with loamy soils as it very significantly increased ($p<0.01$) with clay soils. The effect of land slope was negative and marginally significant ($p<0.1$). Tractor power decreased as the rented land ratio increased, and this relationship was marginally significant ($p<0.1$). The effect of the number of parcels was also found to be negative and but significant ($p<0.05$).

Table 3. Regression analysis results for the factors affecting farmers' decision making on tractor power in surveyed farms.

Tractor power (Hp)	Coefficient	Robust Standard error	T	P value
Farmer age				
40-59 age	-8.628	3.733	-2.310	0.025
60 and above	1.238	7.376	0.170	0.867
Education level				
Primary	13.350	6.556	2.040	0.047
Secondery and above	13.345	7.000	1.910	0.062
Total farmland (ha)	0.027	0.041	0.670	0.508
Number of parcels (number)	-0.667	0.286	-2.330	0.023
The ratio of rented land in total farmland (%)	-0.175	0.097	-1.800	0.077
The ratio of Irrigated land in total farmland (%)	-0.052	0.146	-0.360	0.723
The ratio of Pistachio acreage in total farmland (%)	0.096	0.106	0.910	0.367
Land slope (sloping land)	-7.780	4.285	-1.820	0.075
Stoniness (Stony)	0.982	4.597	0.210	0.832
Soil texture				
Loamy	11.150	5.781	1.930	0.059
Clay	17.966	6.729	2.670	0.010
Constant	65.904	16.732	3.940	0.000

Number of Observations =68; R^2=0.54; F(13:54)=19.8; p=0.000

According to the regression model, when holding all other explanatory variables fixed at their mean values (ceteris paribus), an increase by one unit in number of parcels causes 6.5 units of decrease in tractor power. As stated earlier, in general, the effect of the farmer's education level on tractor power was positive and the farmers with the primary school and secondary or higher degrees had significantly ($p<0.05$) and marginally significantly ($p<0.1$) more tractor power compared to the base group (non-degree) farmers in respective order. Thus, an upward change in education level

from non-degree farmers (base group) to primary or secondary school degree causes about 13 units of increase in tractor power at ceteris paribus. Similarly, [22] observed that the education level of the farmers had significant impact on farmers' tractor purchasing behaviour in Erzurum province. The effect of age, on the other hand, was negative, and tractor power decreases significantly ($p<0.05$) for the 40-59 age group compared to the base (under age 40 years) group: In case all other predictor variables were fixed at their mean values, a shift in farmer age group from the base group to the next higher group causes approximately 8.5 units of decrease in tractor power. This indicates that young farmers are more likely to keep up with the development of mechanization. This finding is contrary to the research results obtained by [23] who found that youth involvement in mechanized agriculture is very low in in Ogun State, South Western Nigeria. Similarly, a change in soil texture from sandy to loamy and sandy to clay causes 11 and 18 units of increases in tractor power respectively, as a 10 percent increase in rented land ratio, tractor power decreases 17.5 units at ceteris paribus (Table 3)

5. Conclusions

This study was conducted to determine the major factors affecting pistachio farmer's decisions regarding the choice of tractor power in Siirt province located in the Southeastern Anatolia Region of Turkey. Following conclusions can be drawn from the study results.

Soil texture is a significant factor on farmers' decision regarding tractor power selection. Thus, the pistachio farmers having heavier textured soils preferred more powered tractors. That is, the heavier the soil texture, the higher the tractor power.

The geography is another determiner of the tractor power selection in pistachio farms. Study results indicate that farmers are inclined to prefer light-duty tractors with the increased land slopes.

Another factor determining the tractor power selection is the land tenure in the pistachio farms in the study area. Farmers with higher shares of rented land preferred light duty tractors.

Farmland fragmentation is another factor significantly affecting farmers' decision against heavy duty tractors. Farmers with more fragmented farmland preferred lighter duty tractors.

Age and education level of the farmers are the demographic factors significantly affecting the farmer decisions on the tractor power. Study results suggest that more educated and younger farmers are inclined to make decisions in favour of heavier duty tractors.

Funding: This research received no external funding.

Acknowledgments: he authors thank Metin Aygün for his assistance during survey implementation.

Conflicts of Interest: The authors declare no conflict of interest.

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