International Scholars Journals

International Journal of Agricultural Economics and Extension ISSN 2329-9797 Vol. 7 (12), pp. 001-006, December, 2019. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Performance evaluation of agricultural inputs in crop production of Zahak Payame Noor university agricultural faculty farm by linear programming

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Accepted 16 May, 2019

Farm management is one of the most critical factors in production and marketing of agricultural crops. In a broad description, management is defined as making decision process through which the limited resources are allocated to competent items in such a way that the determined goal can be achieved. Generally, organizing and controlling the resources of an agricultural unit toward the maximum potential benefits and expected revenues is the main task of farm manager. Furthermore, by increasing population and demand for agricultural crops and relative resource shortages, it will be obvious that efficient input utilization is essential. Today, management science using mathematical programming especially linear programming encourages managers for much more efficient decisions in the field of allocating limited resources to competent activities. Hence, linear programming technique serves as a means for choosing the highest performance items; that is, the items having the highest output to input ratio. Since decision making is crucial in management process, if the linear programming parameter (facilities, limitations, performance and costs) are estimated accurately, the results will have a profound effect on the decision making of the production unit.

Keywords: Inputs, agriculture, production, linear programming.

INTRODUCTION

Singh et al. (1972) using linear programming model provided an optimal cultivation pattern for three regions of Badaon, Nintial and Balia in Otar pradesh state of India. To do so, they selected some of farmers with smaller farmlands (2.5 to 7.5 acres) in a random manner. Planting wheat, maize, rice and beet and selling them was incorporated in the model. The limitations were: irrigated and rainfed land, human labor, animal labor and cash investment. They estimated optimal pattern with and without the cash capital. The results showed that regarding the capital limitations, using limited resources in optimal program relative to the current program can increase net income of retail farmers up to 123, 64 and 41% in Badaon, Nintial and Balia, respectively. If the limitations are not considered, these figures will be 21, 6 and 3% respectively, which indicated the importance of cash capitals in Baodan. Due to differences in net incomes in optimal program relative to current operator situations, the available resources are nit utilized efficiently in smaller farms. In Nintial region, there are excess of labor in all seasons. Therefore, non-agricultural occupational opportunities must be established. In addition, using high yield wheat varieties and paddy not only increases net farm income but also engages more labor and animal that decreases the rate of unemployment. So, the official agricultural advocates should teach the small farmers how to best utilize and logically allocate the resources and accept the modern technologies. The results are listed in Tables 1 and 2.

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Table 1. Performance and income per hectare of each crops.

crop	unit	Irrigated wheat	Rainfed wheat	maize	Sorghum	barley	Alfalfa (forage)
performance	kilogram	5000	750	13000	90000	4000	13500
price	Rial	1350	1350	1100	160	1050	900
Total income	Rial	6750000	1012500	14300000	14400000	4200000	12150000

Table 2. Annual costs per hectare.

crop	unit	Irrigated wheat	Dry wheat	maize	sorghum	barley
Cost (Rial)	1600000	1100000	2910000	2910000	1557500	24100000
Labor costs (Rial)		380000	1390000	1390000	337500	1970000

Sankhayan et al. (1974) provided different cultivation patterns for Punjab state using linear programming model. They aimed at: study cultivation pattern of commercial and food products when there is no limitations for self sufficiency in foodstuffs; developing an appropriate economic model despite the limitations for foodstuffs in commercial products cultivation pattern; and investigation fluctuations in production various commercial and foodstuffs followed by more income considering total values of agricultural crops and self sufficiency need limitations with rare resources of land and fertilizers (Tables 3 and 4).

The required information was gathered by statistical summaries in Punjab and food records. It should be noted that the available output-input information and prices are related to the crop year 1972 to1973 and for foodstuffs to 1970 to 1971.

RESEARCH ESSAY

The general formula for linear programming is as follow:

$$Max: Z = \sum_{j=1}^{n} c_j x_j$$

$$s.t.$$

$$\sum_{j=1}^{n} a_{ij} x_j \leq b_i \qquad i = 1,......,m$$

$$x_j \geq 0 \qquad j = 1,.......,n$$

In the first expression, Z is total programmable yield or fixed input yield which is actually obtained by subtracting variable costs from gross income of suggested program. C_j is the program yield of each unit of j^{th} activity; for example, if hectare is the unit of activity, it will be the program yield of each hectare of j^{th} activity. X_j is the selected activities including crop production, animal husbandry or feeding, production selling, purchasing or hiring services (like l abor and capital), products gathering, transferring input or produce from one activity to another or from one cultivation interval to another and paying fixed costs or family expenses.(Hazek,1979).

In the later expression related to limitations there is three limitations: equal, minimum and maximum. The limitations can be dived into several categories in terms of the goal. The major limitations are:

(a) Resources or inputs including land, labor and capital.
(b) Organizational limitations like governmental plans in crop production allowance.
(c) Emotional factors considered by the operator which is difficult to determine.

b_j is the amount of available input or resources, a_{ij} technical coefficients representing the required resources for each unit of activity and sum of $a_{ij} X_j$ should not exceed the available resources.(Ames,1993).

In the limitation section, the transferred rows are also considered. The transferred rows provide a means whereby the services and produces of an activity within the pattern are transferred to another. (Heady ,1954)

In the third relationship, X_j is nonnegative limitation or in the other word, no activities will be negative. $j = 1,.......,n$ is determined according to the suggested activities in the program and $i = 1,.......,m$ according to the limitations including all kind of limitations make a difficulty in production process.

The linear programming model can be solved by a symmetric procedure firstly provided by Gate et al. (1951). For a producer to develop one or more limited resource, this model is a guideline to recognize the economic limits of the resources. (Bradley et al., 1977).The symmetric pattern can be written as:

$$Min \quad W = \sum_{j=1}^{m} b_i \lambda_i$$

If

$$\sum_{j=1}^{m} a_{ij} \lambda_i \geq Ci \qquad (2)$$

Table 3. Animal number and their needs.

Animal	Heads	Annual required feed (kg)					
		Alfalfa	Silo maize	White straw	Wheat bran	Concentrate	Barley
dairy and pregnant cow	80	116800	438000	29200	-	80000	-
Male and female calves3-6 months	40	18250	-	-	11000	-	-
Female calf6-9 months	40	14600	29200	-	-	-	-
heifer	40	58400	219000	14600	29200	-	-
Male calf 3-6 months	40	18250	-	-	11000	-	-
Male lamb	165	6000	49500	-	9000	-	34650
Ewe) Female lamb)	363168	-	120000	-	-	-	-
Male sheep	46	6000	19500	-	900	-	34500

Table 4. Feedstuff prices (Rial).

alfalfa	Silo maize	White straw	Wheat bran	concentrate	barley
900	160	220	425	1220	100

Table 5. Annual income of animal products.

Dairy cow (head)	80
Average days of lactating	305
Average daily lactating (kilo)	1085
Price (Rial)	1850
Milk sales (Rial)	858400000
Male calf (heads)	40
Male calf selling	137520000
Female calf sales	280000000
Fertilizer amounts for 200 heads dairy and nondairy cattle (ton)	1000
Fertilizer price (Rial) per kg.	60
Manure value (Rial)	60000000
Total cattle farm income (Rial)	1335920000
Male lamb (heads)	155
Male lamb selling (Rial)	139500000
Ewe (heads)	165
Ewe sales (Rial)	95382000
Male sheep (heads)	10
Male sheep selling (Rial)	9450000
Total income of sheep husbandry (Rial)	244322000

and

$$\lambda_i \geq 0$$

In the first expression, b_i is the limited resource, and λ_i the marginal yield of the resources which is called shadow price in linear programming. The model is written as minimum to avoid more sharing than an input yield in production or over investing.

In the second expression, as a condition it guarantees that not less than the share will be given to the resources. So, under investing is avoided. Of course, by primary solving, the answers in the second solving or symmetry can be achieved. (Chen and Baker,1974.Dantzig,1963.Dorfman et al., 1959).

(3)

In the studied unit, each year for feeding animals, maize, alfalfa and barley is included in the cropping program. In fact, these crops are cultivated for the unit consumption rather than to sales market. The limitations of linear programminf for the animal husbandry section involve roofed barn for the cattle and limited pastures for sheep husbandry (Freeman and Lard,1970) Tables 5 and 6.

RESULTS AND DISCUSSION

For solving the mentioned problems “mixed integer

Table 6. Annual costs of animal products (Rial).

Feed costs of male calves till the age of 6 months (40 heads)	21100000
Feed costs of male calves till the age of one year (40 heads)	99743520
Feed costs of heifer (40 heads)	52560000
Feed costs of dairy cattle (40 heads)	279224000
Costs of veterinary and drugs	12000000
Total cattle farm costs	468627500
Feed costs of male lamb till the sale (155 heads)	52883000
Feed costs of sheep	19200000
Costs of veterinary and drugs	6000000
Total sheep husbandry costs	78083000

Table 7. Total regional available water (m^3).

Number of well	Season		
	Spring	Summer	Fall
six 15-in. wells	3615840	3615840	3499200
two 4-in. wells	321408	321408	311040
One 2-in. well	80352	80352	77760

Table 8. Required water amount for each product (m^3).

Crop	Required water (m^3)	No. of irrigation periods
wheat	6000-7000	5
maize	18000-20000	12-15
alfalfa	15000	10
barley	4000	3-4

number programming” method using software packages of *QSB* and *LINGO* was sued. The summarize results are listed in Tables 7 and 8.

As shown in the table, the actual and optimal cultivation patterns for operators in terms of both kind and amount of crops and net unit income are different. In optimal pattern, wheat production has been recommended more than its current amount (about 72%), because wheat rather than other crops, utilizes the limiting inputs much better with a higher yield. In contrast, the cultivated alfalfa area due to its lower income and cultivated area of barley have been reduced to 56 and 15%, respectively. However, for self-consumption about 22 and 17 hectares have been allocated to these two crops, respectively. This self-sufficiency need is recognized as a limitation in the model. Since maize has higher production cost per unit and lower yield relative to other crops in the current pattern, it has been omitted from the optimal pattern and instead higher sorghum cultivation (the most profit crop) has been suggested because its yield relative to its annual costs is improved relative to other crops competing in limited resources. Similarly, in the case of increasing wheat cultivated area the changes in permitted activity yield ranges resulted in optimal situation of the limiting input (water) usages. For this reason, it is likely that if the farm unit is surveyed separately (not in combination with animal farming unit) and lack of self-sufficiency requirement limitation, high yield products such as wheat and sorghum will replace these two crops and it can be suggested that alfalfa and forage are supplied outside the unit to raise the higher yields accessibility will be possible thorough reducing the effective limitations. Regardless the costs and incomes as a main goal for the manager, forage and barley providing facilities in appropriate time, no concern for market prices are among the factors affects decision making in chasing goals (more profit) while the present applied method (linear programming model) have described these items; furthermore, since the studied unit is not a NGO and has more attention to training aspects, earning maximum income like other private units is not an observed priority. In the present program, total cultivated areas for different crops are 500 hectares and in the optimal program 578 hectares showing something about

Table 9. The amount of various crops in the current and optimal program.

Crop	Irrigate wheat (ha)	Sorghum (ha)	Maize (ha)	Alfalfa (ha)	Barley(ha)	Cattle(ha)	Sheep (ha)	Programmed yield (Rial)
Current program	250	100	20	50	20	80	360	4139178000
Optimal program	431	288	0	22	17	80	360	6772462000
Change (%)	72	188	-100	-56	-15	0	0	64

52% increase. Also, in the animal farm station are hold 80 heads dairy cattle and as mentioned earlier, income and costs of heifer and male and female calves is part of the income and costs of dairy cattle. The programmed yield in the current programe with 80 heads is 10841000 Rials per year. Since, dairy cattle is an activity in the model (it is an integer number), regarding the roofed barn limitation and surplus current cultivated alfalfa and barley, the optimal head in the optimal program is the same 80. In this station, there are 360 sheep heads (income and costs of ewes and lambs are part of sheep income and costs). The programmed yield for this 360 heads is equal to 461800 per year. Because the sheep are also considered as an activity in the model, the above mentioned limitations for dairy cattle met also for sheep (integrity of sheep heads, roofed barn and limited space for pasture), sheep heads in the optimal program is the same 360. Accordingly, due to high yield of animal farming unit, it is expected to raise cow numbers following the limitations of roofed farm for the cows will be met. In contrast, for the sheep due to limitations in pastures not controlled by the manager, increasing the number of sheep is not possible at the present time. (McCamley and Kliebenstein,1987).

Therefore, the present conditions are regarded as optimum. In this regard, the results for allowable changes and yield ranges of activities are significant. In fact, when sheep farming yield is lesser than the current level, the optimum amount will be lesser. For cattle unit, this figure is approximately near the current yield. So, if increasing cow numbers decrease the gross yield, after a slight decline in the yield, it is expected the optimum number of cows will be lower than the current. Totally, the program crop and animal yield will be reached to 677246200 from current 413917800 Rials in the optimum program with a ca. 64% increase. It seems achieving this increment will be unexpected when farm and animal units provide the specialized academic labors and using modern management techniques is the minimum expectation regarding the economic purposes in addition to training and educational goals. According to observed results, perhaps in the first step we can appeal replacing the dominant current furrow irrigation with high efficient systems to improve yield of water as the limiting input. In the optimum pattern, about 850 hectares will be cultivated, while in the current pattern only 450 hectares are under cultivation. This is true for increasing the cultivation area by the current (traditional) irrigation systems. Water limitation in spring and summer regarding the massiveness of the crops is serious and as is given in the table, we have surplus water in the fall. As the unit manager indicated, according to the climate of Sistan dam, it is not possible to use this fall surplus water for other applications. The opportunity cost for each unit of surplus water in spring and summer is 717.3 Rials demonstrating needing a rapid move toward increasing available water efficiency more or less. In the above farm unit, besides the described 1000 hectare cultivated areas, there are 120 hectares of rainfed lands which have been allocated to wheat cultivation. Since rainfed wheat is not affected by no means with the given limitations and has a stable condition, it has not been included in the target function.The summarize results are listed in Table 9.

Main reasons for differences between unit actual and optimal pattern

The optimal pattern regardless risk and unreliability factors, allocates maximum resources to cultivation and most profitable crops. This makes a large difference between actual and optimal income of the operators. Selling price is one of the most important parameters assumed constant in the linear programming model. Since, the studied unit is under authority of agricultural faculty, there is no intervention in the output (and input) market and for this reason it is unlikely that selling prices will change with alteration in cultivation pattern. Even it will have no effect on decisions for increasing cultivation of the most beneficent crop. Linear programming model, however, regardless this crucial object, only by recommending cultivation the most profitable crop, raises the operating unit theoretically. (Heady and Candler,1985).

Decisions for cultivation various crops is based on the previous periods data and final approval of the faculty, whereas, the optimal pattern results are obtained by sectional (annual) information.

Hence, the difference between unit actual and optimal incomes may be due to impaired statistical data. So, for final statement on whether the resource allocation is optimum or not, it should be made use of both time series (annual) and sectional information. In addition, for unit behavioral analysis, the linear programming model in conjunction with profit risk must be applied. To do so, price variances, crop yields and technical coefficients in different years can be used to illustrate risk and unreliability factors. Accordingly, resource allocation will be optimum when with price, yield and technical coefficient changes for a crop during different years, the cultivation pattern will be changes proportionately. (Heady,1970).

Furthermore, due to limitations imposed to researcher by mathematical precision instruments, in this study we discussed losses separately (particularly in the animal unit) or other usages comprising about 5% of products in total and majority of them have low market values. Generally, it is suggested 10% current yield for all usage out limited the selling prices. A small area of the farm was also considered for training purposes.

It dare can be said an interesting point in the management is maintaining and reinforcing motivation in managers and colleagues. In the investigated unit, some pinpoints including optimal available water utilization is the primary factor mined directing desirable productivity. The studied unit posses a governmental management causing some limitations and besides this, not reinforcing managers' motivation is an obstacle in the way to improve management themes, and will results in stabilization of non optimum current situations.

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