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Economic Analysis of Gram Cultivation in Pakistan: Implications for Research and Extension

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Abstract: Increasing import bill of pulses can be minimized by enhancing pulses production in the country. Gram is a major pulse of Pakistan and is mainly grown in Bhakkar, Layyah, Mianwali and Khushab districts of Punjab. Continuous decline in area and productivity of gram has led to the need to know the factors responsible for its low production. The information was gathered from 120 farmers through a field survey in Bhakkar and Layyah districts. Cropping intensity and crop diversity index were estimated as 102% and 1.74, respectively. C-44 and Bittal-98 were most popular varieties grown in the area. Mean varietal age was 16.5 years and varietal diversity index was 1.12 indicating extremely slow varietal replacement. Majority of farmers used their own seed and recommended seed rate, while line sowing was practiced by all farmers. The proportion of farmers applying FYM, fertilizer, weedicides and pesticides was extremely low and the quantities applied were also sub-optimal. Productivity per ploughing, weeding, seed and urea applied were about 354 kg, 89 kg, 10 kg and 758 kg, respectively. The overall net income was computed as Rs. 3583 ha^{-1}. Returns per rupee of total and variable cost were almost 73% and 163%, respectively. Factors found significantly affecting gram productivity were urea utilization dummy, number of ploughings, per cent area weeded, planting date and seed rate. Magnitude of coefficient for urea and DAP utilization dummies, number of ploughings and gram sowing date are relatively higher than other variables. This indicates that farmers should focus more on these production practices for increasing gram yield. This also implies a need for stronger farmer-extension interaction, reinforced with increased number of improved production technology demonstration plots. Agricultural research institute in the area may reform its gram breeding agenda in favor of more drought tolerant varieties. The technology diffusion may also be enhanced through collaboration with local agricultural extension department and inputs/seed dealers of the area. In this regard, the replication of success story of Barani Village Development Program of the Punjab province is another option.

Key words: Economic analysis, pulses, gram, diversity, weighted average varietal age.

Pulses are important for improving both the soil and human health. The laxity in pulses research and development has led to the stagnation of their yield and loosing competitiveness in cropping systems. This has led to pushing pulses cultivation to the marginal areas (Ali *et al.*, 2005). In Pakistan pulses are cultivated in about 1.47 Mha area with a production of nearly 1.1 Mt. The per capita availability of pulses in the country is 7.24 kg $annum^{-1}$ (Government of Pakistan, 2007), which is much below the per capita consumption in South Asia, i.e. more than 12 kg $annum^{-1}$ (Ali *et al.*, 2005). The share of Punjab province in total pulses area and production is more than 80%. From 1990-91

to 2006-07, the area, production and yield of pulses in Pakistan grew by -0.36%, 1.83% and 2.19% per annum, respectively. For Punjab, the corresponding growth rates were 0.40%, 3.13% and 2.73% per annum, respectively (Table 1). This signifies that Punjab has been historically contributing to pulses production. Pakistan is a regular importer of pulses and spent 14.84 billion rupees for importing 520.9 thousand tons of pulses during 2006-07. Gram crop can significantly contribute in attaining overall self-sufficiency in pulses production by improvements in gram productivity as the yield obtained is far below the potential yield of varieties cultivated by the farmers.

Gram is a major pulse crop of Pakistan, covering nearly 72% of total pulses area and about 77% of total pulses production in the country. Punjab province is the major contributor with about 86% share in total area and production in the country (Government of Pakistan, 2007). From 1990-91 to 2006-07, the average annual growth in area, production and yield of gram in Pakistan were -0.33%, 2.06% and 2.40%, respectively and for Punjab, the corresponding growth rates were 0.41%, 3.33% and 2.93%, respectively (Table 2). Thus, Punjab is traditionally the major contributor of gram production in the country. Within Punjab province, gram cultivation is mostly confined to Bhakkar, Khushab, Layyah and Mianwali districts. In Khushab and Mianwali districts, it is mainly grown under rainfed conditions, whereas in Bhakkar and Layyah, a notable proportion of gram area is also on irrigated lands. These districts contribute nearly 88% of the total area and production of gram in Punjab, in the country as a whole these four districts contribute 56% and 49% of total gram area and production (Government of Pakistan, various issues).

During the past 17 years (1990-91 to 2006-07), the overall annual growth in area, production and yield of gram in the above four districts were 0.19%, 3.22% and 3.03%, respectively. During the same period, the average annual growth in area, production and yield of rainfed wheat in these districts were -2.51%, -1.57% and 0.94%, respectively. The coefficient of variation in yield (as an indicator of crop productivity risk) in gram and rainfed wheat production in these districts was 28.9% and 29.6%, respectively, indicating less productivity risk in gram production than wheat. The average annual growth in wholesale prices of gram and wheat were 8.82% and 8.46%, respectively. Thus, gram production remained more profitable than wheat in rainfed regions. However, the rate of increase in gram area (0.19% per annum) has been much slower than the decline in area under wheat (-2.51% per annum), which needs monitoring. There is also a need to evaluate the returns from gram production to attract growers towards gram cultivation and faster substitution of area in favor of gram crop.

For institutional support, one Arid Zone Research Institute is located at Bhakkar and one Adaptive Research Station is in Crore Laal Esan tehsil of Layyah district to carry out varietal and adaptive research on pulses, including gram crop. Although, the continuous decline in area and production of gram in Punjab, as well as in Pakistan from 1997-98 to 2001-02 and its slow recovery afterwards has evoked interest in researchers and policy makers, not much could be done for enhancing

Table 1. Area, production and yield of pulses in Punjab and Pakistan

Season	Pakistan			Punjab			Share of Punjab (%)	
	Area (000 ha)	Production (000 t)	Yield (kg ha^{-1})	Area (000 ha)	Production (000 t)	Yield (kg ha^{-1})	Area	Production
1990-91	1538.2	732.1	476	1148.7	526.1	458	74.68	71.86
1991-92	1420.4	706.2	497	1057.0	505.8	479	74.42	71.62
1992-93	1453.1	547.1	377	1103.8	345.1	313	75.96	63.08
1993-94	1480.9	614.0	415	1124.4	408.3	363	75.93	66.50
1994-95	1511.3	777.7	515	1128.7	560.8	497	74.68	72.11
1995-96	1599.0	918.6	574	1208.8	688.6	570	75.60	74.96
1996-97	1574.8	832.4	529	1220.2	625.8	513	77.48	75.18
1997-98	1564.6	1007.4	644	1199.3	793.9	662	76.65	78.81
1998-99	1530.5	951.4	622	1170.3	727.3	621	76.47	76.45
1999-00	1418.9	802.4	566	1096.1	619.7	565	77.25	77.23
2000-01	1329.3	621.4	467	1074.6	487.8	454	80.84	78.50
2001-02	1379.5	593.8	430	1140.0	471.2	413	82.64	79.35
2002-03	1424.0	930.2	653	1207.3	804.0	666	84.78	86.43
2003-04	1456.6	870.8	598	1187.9	711.9	599	81.55	81.75
2004-05	1491.9	1094.2	733	1245.5	927.5	745	83.48	84.77
2005-06	1404.5	684.8	488	1163.2	524.7	451	82.82	76.62
2006-07	1472.3	1089.3	740	1179.1	893.0	757	80.09	81.98
Annual growth	-0.36%	1.83%	2.19%	0.40%	3.13%	2.73%	0.76%	1.30%

Source: Agricultural Statistics of Pakistan, 2006-07.

cultivation of this crop in the country. Realizing the importance of the issue, a study was conducted on economic analysis of gram cultivation in Thal Desert of the Punjab through detailed survey. The specific objectives were:

- To examine the status of production and varietal adoption of gram in the area.
- To provide updated information on gram production practices, inputs, productivity and returns from gram cultivation in the area.
- To investigate the factors affecting gram productivity, production and marketing problems in the area.
- To suggest guidelines to different stake-holders for enhancing gram production in the area.

Research Methodology

As gram crop is mainly cultivated in Khushab, Bhakkar, Layyah and Mianwali districts, the study was carried out in Bhakkar and Layyah districts. Mankera and Chaubara tehsils were selected as the major gram growing tehsils, from where 15 major gram growing villages were randomly selected after consulting the local Agricultural Extension officers. The data on gram production practices and on input-output prices, wage rates, land rent and other operational costs were gathered during

Table 2. Area, production and yield of gram in Punjab and Pakistan

Season	Pakistan			Punjab			Share of Punjab (%)	
	Area (000 ha)	Production (000 t)	Yield (kg ha^{-1})	Area (000 ha)	Production (000 t)	Yield (kg ha^{-1})	Area	Production
1990-91	1091.5	531.0	486	863.5	403.0	467	79.11	75.89
1991-92	996.9	512.8	514	792.8	390.9	493	79.53	76.23
1992-93	1007.6	347.3	345	820.0	227.0	277	81.38	65.36
1993-94	1045.0	410.7	393	844.7	286.4	339	80.83	69.73
1994-95	1064.5	558.5	525	846.1	425.4	503	79.48	76.17
1995-96	1118.9	679.6	607	896.6	537.5	599	80.13	79.09
1996-97	1100.2	594.4	540	906.4	472.6	521	82.39	79.51
1997-98	1102.3	767.1	696	908.3	646.2	711	82.40	84.24
1998-99	1076.9	697.9	648	887.6	577.7	651	82.42	82.78
1999-00	971.8	564.5	581	809.2	465.5	575	83.27	82.46
2000-01	905.0	397.0	439	780.1	334.8	429	86.20	84.33
2001-02	933.9	362.1	388	816.0	304.2	373	87.38	84.01
2002-03	963.0	675.2	701	860.0	611.5	711	89.30	90.57
2003-04	982.3	611.1	622	854.4	524.0	613	86.98	85.75
2004-05	1093.9	868.2	794	956.4	760.6	795	87.43	87.61
2005-06	1028.9	479.5	466	900.1	382.5	425	87.48	79.77
2006-07	1052.3	837.8	796	910.7	728.3	800	86.54	86.93
Annual growth	-0.33%	2.06%	2.40%	0.41%	3.33%	2.93%	0.74%	1.27%

rabi 2003-04, using a pre-designed questionnaire. For this, 120 producers of the crop were randomly selected from the 15 villages. The sample farmers were classified into small (<5 ha), medium (5 to 10 ha) and large (>10 ha) farmer categories. The sample composition across districts is given in Table 3.

Besides the standard descriptive analysis by farm size categories, the cropping pattern was computed as:

$$PA_1 = \frac{AR_i}{\sum_{i=1}^{n} AR_i} x100$$

where,

PA_i = Per cent of total cropped area under *ith* crop in a cropping season, AR_i = Total area under *ith* crop in a cropping season, $\sum AR_i$ = Total cropped area (sum of area under various crops) in a cropping season.

The cropping intensity was estimated using the following formula:

$$CI = \frac{\sum_{i=1}^{n} AR_i}{CA} \times 100$$

where,

CI = Cropping intensity, AR_i = Area under *ith* crop, CA = Total cultivated area.

Table 3. Composition of sample gram crop growers by farm size and district in Thal Desert of Punjab

Farm size group	District		All	Average farm size (ha)
	Bhakkar	Layyah		
Small	8 (14.8)	13 (19.7)	21 (17.5)	3.05
Medium	14 (25.9)	19 (28.8)	33 (27.5)	8.12
Large	32 (59.3)	34 (51.5)	66 (55.0)	24.55
All	54 (45.0)	66 (55.0)	120 (100.0)	39.60

Note: In columns 2-4, figures outside parentheses are number of respondents and inside parentheses percentages.

The weighted average varietal age (VARAGE) was estimated using the following formula:

$$VARAGE = \sum_j PAV_j \times AGEV_j$$

where,
VARAGE = Weighted average varietal age of gram varieties planted, PAV_j = Per cent of total gram area occupied by its *jth* variety, $AGEV_j$ = Period in years of *jth* gram variety since its release.

This index was also used by Heisey (1990) and Hartell *et al.* (1998) for estimating the contribution of wheat breeding efforts in Pakistan.

For calculating crop diversity index, the following inverse Herfindahl Index (Patil and Taillie, 1982) was used:

$$CDI = \frac{1}{\sum_{i=1}^{n} S_i^2}$$

where,
CDI = crop diversity index, S_i = the share of individual crop in total cropped area.

The same formula was also used for calculating varietal diversity index.

To understand the factors responsible for gram cultivation in the area, multiple regression analysis was conducted. The yield per hectare was taken as dependent variable. Independent variables were total operational holding, weighted average varietal age, ploughing, gram planting date, seed rate applied, per cent gram area manually weeded, farmer education, and dummies for district, urea and DAP application.

Results and Discussion

Cropping pattern

Gram, wheat and rabi fodders are the major rabi crops occupying 92% of total farm area during the season. In kharif, clusterbean, mung bean and kharif fodders account for only 7% of the total farm area while 91.5% area remains fallow. The cropping intensity was estimated to be 102% and crop diversity index 1.74. High temperature, non-availability of canal water and limited opportunities of tubewell irrigation in the area are the main reasons for low cropping intensity. Cropping intensity and crop diversity index were inversely related to farm size, indicating that small farmers were not only more intensively cultivating their lands but their farming was also more diversified than their counterparts (Table 4).

Gram varietal distribution

The introduction of high yielding varieties and the rate at which they are

Table 4. Cropping patterns (% area by season), cropping intensity (%) and crop diversity index by farm size categories in Thal Desert of Punjab

Season/Crop	Farm size			All
	Small	Medium	Large	
Rabi season				
Gram	69.0	59.0	77.5	75.6
Wheat	20.9	26.1	13.5	14.8
Rabi fodder	5.8	3.4	1.2	1.5
Onion	1.4	0.2	0.7	0.6
Sugarcane	0.0	0.2	0.5	0.4
Orchard	0.0	0.0	0.4	0.3
Mustard	0.0	0.9	0.0	0.1
Lentil	0.0	0.1	0.0	0.0
Fallow	2.7	10.2	6.3	6.6
Kharif season				
Clusterbean	4.1	1.7	2.6	2.6
Mung bean	3.8	8.2	1.9	2.5
Kharif fodder	4.6	4.8	1.8	2.2
Cotton	0.6	1.2	0.5	0.6
Rice	0.0	0.2	0.4	0.4
Orchards	0.0	0.0	0.2	0.2
Vegetables	0.0	0.0	0.1	0.1
Sesame	0.6	0.3	0.0	0.0
Fallow	86.3	83.6	92.5	91.5
Cropping intensity (%)	110.9	106.3	101.2	101.9
Crop diversity index	2.32	2.64	1.65	1.74

diffused to farmers' fields indicate the speed of transferring the benefits of breeding efforts to farmers. Varietal replacement has been generally very slow in Pakistan, although farmers quickly adopted semi-dwarf wheat varieties at the time of the Green Revolution in the late 1960s. Various measures such as the number of varieties planted, varietal age, per cent area under newly released varieties and varietal diversity are used to estimate the extent of varietal adoption (Farooq and Bashir, 2000). In the study area, C-44 followed by Bittal-98 were the most popular gram varieties on sample farmers' fields. About 27% of the total gram area was planted under varieties released in the past five years. Mean varietal age was estimated to be 16.5 years and varietal diversity index 1.12. About 82% of the farmers planted only one variety of gram (Table 5). The very high value of gram varietal age indicates extremely slow process of variety replacement in the area. This also indicates limited access to newly released varieties. Moreover, those having seeds of new varieties are not cultivating on a larger area.

Table 5. Varietal composition (% gram area) and varietal adoption indicators by farm size categories in Thal Desert of Punjab

Varieties	Farm size			All
	Small	Medium	Large	
Varietal composition (% area)				
C-44	77.1	80.9	68.3	69.4
Bittal-98	17.4	16.6	27.4	26.4
Punjab-2000	0.0	0.0	0.7	0.6
Noor-91	0.0	2.0	0.7	0.6
CM-98	0.0	0.0	0.6	0.5
Desi	5.5	0.0	0.4	0.5
CM-72	0.0	0.0	0.4	0.4
Punjab-91	0.0	0.3	0.0	0.0
Don't know	0.0	0.1	1.7	1.6
Variety adoption indicator				
% area under 5 years old varieties	17.4	16.6	28.0	26.9
Weighted varietal age (years)	18.1	16.8	15.9	16.5
Varietal diversity index	1.0	1.1	1.2	1.1
No. of varieties planted				
One variety	100.0	84.4	76.1	82.5
Two varieties	–	15.6	16.4	13.3
More than two varieties	–	–	7.5	4.1

Seed source

Majority (69%) of the farmers used the seeds retained from previous year's crop, while almost one-fourth farmers purchased fresh seed from dealers. A small number of farmers approached Punjab Seed Corporation and Agricultural Research Stations for obtaining certified seeds of improved high yielding varieties (Table 6).

Gram production practices on sample farms

Information about gram production practices is presented in Table 7. The seedbed preparation operations consisted mainly of joint application of ploughing and planking [The plank (i.e. a long and heavy wooden bar) is tied behind the tines of cultivator while ploughing with tractor], and ploughing with cultivator. Overall, 1.43 and 0.59 passes of cultivator plough and plank were applied. Relatively more number of passes were applied by small and medium sized farmers. The mean planting date was 14th October, indicating that the farmers spread seed before the onset of the rabi season. The mean seed rate applied was about 52 kg ha^{-1}, which was slightly above the agricultural department's recommended seed rate of around 50 kg ha^{-1}. About 55% of the total gram area was planted with seed drill and remaining by *kera* (i.e. manually dropping seed in furrows) method. Thus, line sowing is practiced by all the growers. Medium sized farmers planted more gram area by drill method.

Table 6. Source of seed (% farmers) by farm size categories in Thal Desert of Punjab

Source	Farm size			All
	Small	Medium	Large	
Own	71.4	66.7	69.7	69.2
Seed dealers	14.3	27.3	25.8	24.2
Fellow farmers	14.3	6.1	1.5	5.0
Punjab Seed Corporation	0.0	3.0	1.5	1.7
Agri. Research Station	0.0	0.0	1.5	0.8
NRSP (National Rural Support Program)	0.0	0.0	1.5	0.8

Note: Column sum shall not be equal to 100 because some respondents reported more than one

In the sample households, animal dung (or dung cakes) was used to supplement the firewood as fuel. This left a smaller amount of farmyard manure (FYM) for field crops. Overall, only 2.5% farmers reported applying FYM to gram crop. Only 0.2% of the total gram area received FYM and the mean rate of application was 0.012 trolley ha^{-1}. Only 13.4% sample farmers applied fertilizer with equal proportion of farmers using urea and DAP (i.e. 6.7%). The average quantities applied were 0.67 and 0.37 kg ha^{-1} of urea and DAP, respectively. More than 85% farmers manually weeded their crop and the average weeding time was 5.68 man days ha^{-1}. The pesticides and weedicides were applied on hardly 1% and 0.1% of the total gram area, respectively. The crop was harvested in the first week of April and the entire crop was manually harvested, but threshed mechanically. Since almost the entire crop was mechanically threshed, the mean threshing labor time was estimated as 1.01 man days ha^{-1}.

Gram productivity

The gram output per ploughing, seed quantity, urea and weeding time were estimated as 353.80 kg, 9.74 kg, 758.33 kg and 89.02 kg, respectively (Table 8). At large farms, the ploughing, urea and weeding productivity was relatively high whereas on medium farms, the seed productivity was relatively high. The higher seed productivity at medium farms could be partly attributed to better viability of the seed applied.

Cost, revenue and returns from gram production

The average farm size of sample farmers was 39.60 ha (Table 3), of which about 76% area was planted under gram during rabi season (Table 4). Large farmers devoted more area to this crop. The hectare based cost and returns of gram production are presented in Table 9. The gross value of output was composed of the value of grain estimated at farm gate price and the imputed value of the gram straw. The expenses incurred on variable and fixed inputs were estimated in terms of imputed and purchased costs. Net income was estimated by deducting total cost (variable cost+fixed cost) from the gross value of output. It was found that the sample farmers had produced gram of gross value amounting to Rs. 8498.93 per ha. The average variable and fixed costs were estimated as Rs. 3232.39 per ha and Rs.1684.63 per ha, respectively, making total cost as Rs. 4917.02 per ha. The overall net income was computed as Rs. 3581.91

Table 7. Gram production practices by farm size groups in Thal Desert of Punjab

Item	Unit	Farm size			All
		Small	Medium	Large	
Seedbed preparation					
Application					
- Leveling	% gram area	3.66	7.80	1.20	1.72
- Deep ploughing	% gram area	0.00	0.00	0.60	0.54
- Ploughing	% gram area	64.30	49.74	47.22	47.74
- Planking	% gram area	2.75	0.26	1.18	1.14
- Ploughing+planking	% gram area	71.40	78.77	79.24	79.06
No. of passes/tractor hours applied					
- Leveling	Hours/ha	0.34	0.42	0.10	0.22
- Deep plougings	No.	0.00	0.00	0.01	0.00
- Cultivator ploughing	No.	1.62	1.54	1.31	1.43
- Planking	No.	0.67	0.67	0.53	0.59
- Total number of operations*	No.	2.29	2.22	1.85	2.03
Seed rate and sowing method					
- Sowing time	Mean date	14th Oct.	15th Oct.	14th Oct.	14th Oct.
- Seed rate	kg ha^{-1}	51.42	51.59	52.26	51.94
- Sowing by drill	% gram area	46.45	71.87	53.40	54.55
- Sowing by *Kera*	% gram area	53.55	28.13	46.60	45.45
Manure and fertilizer application					
User percentage					
- Farmers apply FYM	% farmers	0.00	6.10	1.50	2.50
- Farmers applying fertilizer	% farmers	9.60	18.20	12.20	13.40
- Farmers applying Urea	% farmers	4.80	9.10	6.10	6.70
- Farmers applying DAP	% farmers	4.80	9.10	6.10	6.70
- Farmers applying both	% farmers	–	–	–	–
Application					
- Farmers apply FYM	% gram area	0.00	1.53	0.10	0.20
- Farmers applying urea	% gram area	1.37	1.79	0.80	0.88
- Farmers applying DAP	% gram area	0.92	4.60	0.66	0.94
Quantity applied					
- FYM	Trolley ha^{-1}	0.00	0.07	0.00	0.00
- Urea	kg ha^{-1}	0.84	1.26	0.62	0.67
- DAP	kg ha^{-1}	0.57	1.68	0.25	0.37
Plant protection					
Application					
- Pesticide applied	% gram area	3.20	2.05	0.56	0.72
- Weedicide applied	% gram area	0.00	0.00	0.10	0.09
- Manual weeding applied	% gram area	82.61	84.14	85.36	85.22
- Manual weeding	Man-day ha^{-1}	6.18	6.30	5.19	5.68
Harvesting and threshing					
- Harvesting date	Mean date	10th Apr.	8th Apr.	7th Apr.	8th Apr.
- Harvesting method - manual	% gram area	100.00	100.00	100.00	100.00
- Threshing method - mechanical	% gram area	89.93	96.42	99.90	99.46
- Harvesting labor	Man days ha^{-1}	6.70	7.93	7.14	7.29
- Threshing labor	Man days ha^{-1}	2.05	0.69	0.84	1.01
Yield	kg ha^{-1}	491.26	546.61	490.27	505.94

* Total number of operations=deep ploughings+cultivator ploughings+plankings.

Table 8. Gram inputs productivity per ha by farm size groups in Thal Desert of Punjab

Production practice group	Unit	Farm size			All
		Small	Medium	Large	
Ploughing	kg gram/ploughing	303.24	354.93	374.26	353.80
Seed	kg gram/kg seed	9.55	10.59	9.38	9.74
Urea	kg gram/kg urea	584.74	433.75	793.64	758.33
Weeding	kg gram/man-day	79.52	86.75	94.48	89.02

per ha. The net income was higher on medium sized farms, mainly due higher yield. The returns to per rupee investment and returns to per rupee spent on variable cost were estimated to be about 73% and 163%, respectively. These returns were relatively high on large farms than their counterparts.

Fixed costs constituted the highest share (34.26%), followed by a decreasing order of groups of production practices as seed and seed sowing, harvesting and threshing, seedbed preparation, plant protection, and FYM and fertilizer application. This implies that the farmers are not incurring due expenses on two important production practices, i.e. fertilizer and plant protection.

Factors affecting gram yields: Results from regression analysis

In order to find out the factors affecting gram yields in the study area, a multiple regression analysis was performed. Mean gram yield (GRAMYLD) was estimated in terms of kg ha^{-1} and taken as dependent variable. On the independent side, the variables included:

OPERHOLD : Total operational holding (ha)

GVARAGE : Weighted average age of gram varieties planted (years)

NPLOW : Cultivations applied with cultivator (Nos.)

GSOWDATE : Gram planting date (week of the year)

GSEEDQPA : Seed rate applied (kg ha^{-1})

WEEDPCT : Per cent gram area manually weeded (%)

EDUCATE : Formal education of the farmer (years of schooling)

DAPUSE : Dummy for DAP used (1=if applied; 0= otherwise)

UREAUSE : Dummy for urea used (1=if applied; 0=otherwise)

DISTCODE : Dummy for the district (1=Bhakkar; 0=Layyah)

The mean formal schooling of sample farmers was 5.71 years. From the regression analysis, it was found that the signs of the majority of the variables were according to the *a priori* expectations. The 0.33 value of adjusted R^2 implies that the regression-included variables encompassed one-third of the variation in gram yield. The factors significantly affecting gram production were, dummy for urea application, number of cultivations applied, per cent gram area manually weeded, planting date, seed rate applied and district dummy. The statistically non-significant factors include farm size, dummy for DAP application (significant

Table 9. Cost and returns (Rs. ha^{-1}) of gram production by farm size groups in Thal Desert of Punjab

Operation	Farm size			All
	Small	Medium	Large	
Seedbed preparation	717.75 (14.25%)	815.06 (15.31%)	564.45 (12.07%)	660.20 (13.43%)
Seed and seed sowing	1087.34 (21.58%)	1143.26 (21.47%)	1156.65 (24.74%)	1140.86 (23.20%)
Manure and fertilizer application	80.87 (1.61%)	163.90 (3.08%)	51.56 (1.10%)	87.60 (1.78%)
Plant protection	504.80 (10.02%)	530.28 (9.96%)	405.59 (8.68%)	457.23 (9.30%)
Harvesting and threshing	955.26 (18.96%)	963.89 (18.10%)	825.93 (17.67%)	886.50 (18.03%)
Total variable cost	3346.03 (66.42%)	3616.38 (69.91%)	3004.19 (64.27%)	3232.39 (65.74%)
Total fixed cost	1691.72 (33.58%)	1708.62 (32.09%)	1670.37 (35.73%)	1684.63 (34.26%)
Total cost (variable+ fixed)	5037.75	5325.00	4674.56	4917.02
Gross revenue	7932.11	9159.16	8349.16	8498.93
Net-income ha^{-1}	2894.33	3834.15	3674.62	3581.91
Net-income against variable costs (Rs. ha^{-1})	4586.05	5542.77	5345.00	5266.54
Returns/Rs. investment (%)	57.45	72.00	78.61	72.85
Returns/Rs. of variable cost (%)	137.06	153.27	177.92	162.93

Note: The prices used in estimation pertain to 2003-04 crop year. Figures in parentheses are proportions of the inputs cost of the respective group in total cost of production.

at 20% level), varietal age and farmer's education. Quantitatively, the magnitude of the coefficient for urea and DAP utilization dummies, number of ploughing and gram sowing date are higher than other variables (Table 10). This implies that farmers' focus on these production practices can substantially help in increasing their productivity.

All the variables listed in the statistically significant group collectively signify the weak interaction of the department of agricultural extension with the farmers. The statistical non-significance of the coefficient for the varietal age was mainly due to the cultivation of only one variety, which is again attributed to weak technology transfer programs and non-existence of seed marketing system in the area.

Gram production and marketing problems

Harsh weather conditions and incidence of pests were the most frequently reported problems in the area. Water shortage was also reported by 9.2% farmers and higher more concern was shown by medium and large farmers. Other minor problems reported were high production cost, difficulties in availability of good quality seed, weed abundance, inadequate gram production knowledge, non-availability of

Table 10. Result of multiple regression analysis of gram production in Thal Desert of Punjab

Items	Coefficient	t-statistics	Significance
Intercept	-1451.089	-1.865	0.065
Dummy for urea application	77.039	2.985	0.004
No. of cultivator plowings applied	20.177	2.634	0.010
Per cent area manual weeding	0.433	1.976	0.051
Gram sowing date	14.625	1.908	0.059
Seed rate	4.485	1.865	0.065
Operational holding	-0.123	-1.567	0.120
Dummy for DAP application	33.896	1.323	0.189
Weighetd average varietal age	-0.973	-0.931	0.354
Farmer's education	1.024	0.766	0.445
District dummy	33.535	2.221	0.028
Adjusted R^2		0.328	
F-Ratio	6.710		0.000

soil testing facilities and poor soil fertility (Table 11).

Majority of farmers (91%) sold the produce at temporary grain procurement shops at transport pickup point or in the nearby town or to village dealers. The average marketing cost was estimated as Rs. 14 per 100 kg bag. Majority of farmers were unable to respond on various marketing problems reported in Table 12. Whosoever responded, reported the marketing problems in decreasing order: the following buyers' collusion, large daily-based and shop-to-shop variations in the prices offered, over-weighing and dishonesty while calculating the money value of the produce sold. More or less same can be observed across farm size categories (Table 12).

Summary and Conclusions

Gram is a major pulse crop of Pakistan as well as of Punjab. Within Punjab, gram is most cultivated in Bhakkar, Khushab, Layyah and Mianwali districts and these districts, which from the backbone of the pulses sector of Pakistan. There is a need to generate empirical statistics on gram varietal adoption, input productivity, production and marketing problems, as no such information is available at present. The present study in Bhakkar and Layyah districts reveals the cropping intensity and crop diversity index as 102% and 1.74, respectively, and both were inversely related to farm size. C-44, followed by Bittal-98 were the most popular gram varieties grown in the area. Mean varietal age of 16.5 years and varietal diversity index as 1.12 indicated extremely slow pace of varietal replacement and planting of newer varieties at proportionately small area. Majority of farmers used their own seed. The proportion of farmers applying FYM, fertilizer, weedicides and pesticides was extremely low and the quantities applied were also sub-optimal. Majority of farmers confine to manual weeding followed and weedicide use was extremely low. The overall net income per hectare was computed as Rs. 3582. The returns to per rupee invested

Table 11. Gram production problems (% farmers reported) by farm size groups in Thal Desert of Punjab

Production problems	Farm size			All
	Small	Medium	Large	
Harsh weather conditions	61.9	45.5	50.0	50.8
Pest problems	33.3	36.4	45.5	40.8
Water shortage	–	9.1	12.1	9.2
High production costs	9.5		9.1	6.7
Quality seed availability problem	4.8	3.0	6.1	5.0
Abundance of weeds	–	9.1	3.0	4.2
Lack of production knowledge	–	–	4.5	2.5
Lack soil testing facility	–	3.0	–	0.8
Poor soil fertility	–	3.0	–	0.8

Note: the sum of column percentages may exceed 100% because of multiple problems reported by farmers.

and returns to per rupee spent on variable costs were about 73% and 163%, respectively.

Investigations into factors affecting gram yield revealed that the magnitude of the coefficient for urea and DAP utilization dummies, number of ploughings and gram sowing date were relatively higher than the other variables. Therefore, farmers' focus on these production practices can substantially help increasing productivity of gram crop. Harsh weather and incidence of pests were the most frequently reported problems in the area. Majority of farmers sell their produce at the temporary grain procurement shops in towns or to village dealers. Buyers' collusion and varied prices offered are major marketing problems.

The results highlight weak interaction between agricultural extension and the farmers. The statistical non-significance of the coefficient for the varietal age was attributed to weak technology transfer programs and virtually non-existence of seed marketing system in the area. Therefore, a strong farmers-extension interaction is

Table 12. Gram marketing problems by farm size groups in Thal Desert of Punjab

Items	Town shop keepers/ dealers	Commission agent	All
Per cent farmers selling	90.8	9.2	100.0
Marketing cost (Rs. per 100 kg bag)	13.50	14.00	13.55
Marketing problems (per cent farmers)			
- Collusion among buyers	42.3	62.5	47.1
- Large variations in prices offered	38.5	0.0	25.3
- Less weighing	11.5	25.0	17.7
- Miscalculations	7.7	12.5	10.0
- Missing responses (% cases)	88.1	63.6	85.8

Note: The sum of column percentages may exceed from 100% because of multiple problems reported by farmers.

necessary for increasing gram productivity. This interaction should be further reinforced by increasing the number of plots demonstrating improved production practices. The agricultural research institute of the area should reform its gram breeding agenda in favor of more drought-tolerant varieties. The improved gram cultivars and technologies should be diffused early in the area by making joint projects with local agricultural extension departments and involving inputs/seed dealers of the area. The success story of Barani Village Development Program (BVDP) of Agency for Barani Areas Development (ABAD) may also be replicated in the area.

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