Himachal Journal of Agricultural Research 37 (2): 198-209, 2011

Impact assessment of wheat research in Himachal Pradesh- contribution of CSKHPKV

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Abstract

This study is the outcome of a NAIP project entitled, "Visioning, Policy Analysis and Gender (V-PAGe)" being executed in CSK HPKV to evaluate impact of scientific technologies developed by the university. In this paper an attempt has been made to assess the adoption and performance of newly released wheat varieties (HPW 184 and HPW 155). Based upon the field survey of 20 villages in Kangra and Mandi districts it was found that wheat varieties HPW-184 and HPW-155 not only gave higher yield over common varieties under both irrigated and unirrigated conditions but were also found fairly resistant to yellow rust, Karnal and hill bunt. These varieties were more input responsive and gave 17.25% higher yield over common varieties grown by farmers. Overall, the returns on R&D expenditure (including AICWIP) came out be Rs. 352.30 lakh with, benefit cost ratio 1.28 and internal rate of return 36.75%. The adoption rate in mid hills of these two varieties was about 18 per cent which could have been higher had the state agencies multiplied seeds of these varieties in appropriate quantity. There are number of constraints viz. lack of irrigation, erratic/ deficit rabi season rainfall, inadequate seed distribution mechanism, emergence of new biotic and abiotic stresses and poor adoption of package of practices in wheat crop. Both short term and long term strategies need to be implemented to increase the wheat production in the state.

Key words: Production function, technical change, elasticity, marginal product, cost of production, benefit-cost ratio and internal rate of returns.

Introduction

Wheat, which accounts for 38.5 per cent of the gross cropped area is the most important crop in Himachal Pradesh. It is grown in all the districts, the most prominent wheat growing districts are Kangra, Mandi, Bilaspur, Hamirpur and Una. Despite ongoing process of diversification of agriculture towards fruits and vegetable crops, wheat continues to remain the major crop in Himachal Pradesh. In most of the districts it is grown in rabi season barring Lahaul & Spiti where wheat is cultivated in summer season from April to September. Since the establishment of Agricultural University at Palampur, wheat research has remained the major mandate of the university. The university has developed a number of wheat varieties for cultivation under irrigated as well as rainfed conditions. The most prominent ones are; Aradhana (HPW -42), Surabhi (HPW-89), HPW-147, Chandrika (HPW-184), and Onkareshwar (HPW-155). Besides this, university

is also testing and recommending varieties developed by other institutions. However, the impact of these varieties on wheat production and productivity in the state has not been examined. Therefore, this study has been undertaken to assess the impact of new technology developed by the university, compute economics of R & D expenditure on wheat, identify major constraints inhibiting the transfer of improved wheat technology to the farmers and suggest strategies for boosting wheat production in the state.

Objectives

The specific objectives of the study are as under.

(i) To examine the production potential of newly released wheat varieties and assess their impact on wheat production and productivity

(ii) To compute the economics of R& D expenditure on wheat in recent years

(iii) To identify the constraints for enhancing wheat production in Himachal Pradesh.

Data and Methods

This study is a part of an ICAR (NAIP) project entitled, "Visioning, Policy Analysis and Gender (V-PAGe)" being executed in CSK HPKV to evaluate impact of scientific technologies developed by the university. Kangra and Mandi districts of Himachal Pradesh were purposively selected as these districts account for more than two-fifths of the area under wheat crop. To begin with, the list of villages around research stations of the university was compiled with the help of scientists and revenue officials. The villages were divided into two strata viz., within 5 km of research institution and beyond. A sample of 20 villages was selected randomly that included 10 each from Kangra district and Mandi districts (5 within and 5 beyond 5 km from research station). The list of farmers who were growing HPW-155 and HPW-184 (newly released varieties) along with other varieties of wheat was prepared with the help of agricultural officials and scientists from research stations and KVKs located near the selected villages. In the second stage, a sample of 50 farm households was proportionately allocated among the selected villages with a minimum of 2 from each of the selected villages. The allotted farmers were then randomly selected. The primary data were collected from sample households on a well-designed survey schedule during rabi season 2008-09. Besides this, secondary data on area and production of crop over time, technology development, seed production and distribution mechanism and constraints, etc., was drawn from published/unpublished reports of CSKHPKV and State Department of Agriculture.

The data was analyzed by employing both tabular and statistical techniques. Simple statistical tools like averages, percentages and ratios were employed. To examine the impact of technology in wheat production; multiple regression analysis was used. Based upon

the goodness of fit (R^2) and plausible signs and significance of individual coefficients, the linear function was found to be statistically more appropriate. The linear production function of the following type was used:

$Y_l = a_l + b_{1l}X_{1l} + b_{2l} X_{2l} + b_{3l}X_{3l} + b_{4l}X_{4l} + u_l$ local/common variety

$Y_h = a_h + b_{1h}X_{1h} + b_{2h} X_{2h} + b_{3h}X_{3h} + b_{4h}X_{4h} + u_h$ improved variety (HPW-155& HPW-184)

$Y_p = a_p + b_{1p}X_{1p} + b_{2p} X_{2p} + b_{3p}X_{3p} + b_{4p}X_{4p} + b_5D + u_p$ pooled

Where;

Y = Yield (q/ha) of crop under consideration

X_1 = FYM (q/ha)

X_2 = Fertilizer (NPK, kg/ha)

X_3 = Irrigations (Number)

X_4 = Human labour (days/ha)

D = Dummy variable viz., 0 for local and 1 for improved variety

u = error term

a = Constant

b_1, b_2, b_3, b_4 and b_5 are regression coefficients (marginal productivities) Suffix l stands for local technology, h for new variety (HPW-155 and HPW 184) and p for pooled function for local and high yielding varieties. Decomposition method was employed to assess the impact of new technology. The decomposition model helps in assessing whether change in yield is due to superiority of new variety/technology or is due to increased use of inputs. Based upon regression coefficients the components of change in yield can be separated as given below:

$(Y_h-Y_l) = (a_h - a_l) + \Sigma(b_{ih} - b_{il}) X_{il} + \Sigma (X_{ih} - X_{il}) b_{il}$

where;

(Y_h-Y_l) = Total change in yield (q/ha)

$(a_h - a_l) + \Sigma(b_{ih} - b_{il}) X_{il}$ = change in yield due to improved technology (q/ha)

$\Sigma (X_{ih} - X_{il}) b_{il}$ = change in yield due to increased use of different inputs under consideration (q/ha).

The elasticities, marginal productivities and factor price ratios were also estimated to examine resource use efficiency. The discounting method was also used to examine the returns to R & D investment on wheat research in the state.

Trends and status of wheat production

The area under wheat has marginally decreased from a peak level of about 376 thousand hectares in 1990-91 to 349 thousand hectares in 2006-07 (Table 1). This is attributed to shift in area from wheat to commercial crops mainly vegetables in districts like Shimla, Kullu, Sirmaur and Solan. The production shows much larger year to year fluctuations with merely 251 thousand tonnes during severe draught year of 2000-01 to a peak level of about 687 thousand tonnes in 2004-05. Resultantly, the yield also showed high year to year fluctuations; it varied from as low as 6.93 q/ha in 2000-01 to 19.46 q/ha in 2004-05. The yield of wheat in the state has always remained much below the national average over the period.

Table 1. Area, production and yield of wheat in Himachal Pradesh

Year	Area (000' ha)	Production (000' tonnes)	Yield (q/ha)
1990-91	376.28	601.72	15.99
1995-96	357.72	502.00	14.03
2000-01	362.68	251.32	6.93
2001-02	366.52	637.07	17.38
2002-03	359.44	495.56	13.79
2003-04	363.37	496.93	13.68
2004-05	353.29	687.45	19.46
2005-06	346.15	365.89	10.57
2006-07	349.60	596.49	17.06

Source: (i) Annual Season and Crop Reports, Various Issues
(ii) Economic Review Himachal Pradesh

Status of R & D in wheat technologies

The hills constitute the hot spot or focus of infection for stripe (yellow) rust in the Indo-Gangetic plains, the 'wheat bowl' of the country. Therefore, the development of stripe rust resistant cultivars in the hills is essential to protect the wheat crop from this destructive disease by decreasing the primary inoculum. For this reason, these diseases require constant vigilance and attention from the breeders. Over the years, major thrust of the university has been on the development of improved varieties of wheat suitable for cultivation under rainfed conditions in hilly regions, especially in mid-hills. Presently, All India Coordinated Wheat Improvement Project (AICWIP) is in operation at Research Station, Malan (Kangra) and Regional Research Station, Dhaulakuan (Sirmour). Over the period, budget flow under AICWIP has increased from Rs. 31.18 Lakh in 2000-01 to Rs. 46.37 Lakh during 2007-08 (Table 2).

Table 2. Expenditure on wheat research at CSKHPKV under All India Coordinated Wheat Improvement Project (AICWIP)

Year	Budget Allocation (Rs.)			
	Plant Breeding	Dhaulakuan	Malan	Total
2000-01	4,13,451	2,01,078	25,04,000	31,18,529
2001-02	4,13,451	2,01,078	25,04,000	31,18,529
2002-03	7,16,637	12,63,592	21,25,555	41,05,784
2003-04	7,16,637	12,63,592	21,25,555	41,05,784
2004-05		18,85,719	23,29,732	42,15,451
2005-06		15,46,686	25,97,310	41,43,996
2006-07		15,29,106	27,15,035	42,44,141
2007-08		15,29,106	31,08,000	46,37,106

Source: Comptroller Office, CSK HPKV, Palampur

The two varieties developed recently by the university are Chandrika (HPW-184) released in 2003 and Onkareshwar (HPW-155) in 2005. These have been found to have wider adaptability, high yield potential and fairly resistant to yellow rust, Karnal and hill bunt. Based on seed multiplication and distribution in mid hill zone, HPW-184 is grown on 11.54 per cent while HPW-155 (recent variety) is grown on 6.80 per cent of the total area under wheat in mid hill zone. The major characteristics of these two varieties and their adoption level are shown in Table 3. The new varieties of wheat have been well accepted by the farmers due to their desirable traits. The multiple responses and composite index of multiple score reveal that these varieties were superior to older ones in terms of yield, quality of grain, disease resistance and high response to inputs (Table 4). The composite index of these varieties clearly shows the social acceptability of these varieties that would favour their adoption in future too.

Table 3. Salient features of new wheat varieties released by CSKHPKV

Variety	Year of release	Yield Potential (q/ha)	Special features	Adoption rate (%)
HPW-184 (Chandrika)	2003	40.5 (18.7)*	Suitable for timely sown irrigated and rainfed conditions of low and mid hills, high yielding, fairly resistant to hill bunt, Karnal bunt and loose smut	11.54
HPW-155 (Onkareshwar)	2005	40-45 (22.0)	Suitable for timely sown irrigated and rainfed conditions of low and mid hills, high yielding, high degree of resistance to diseases, drought and lodging, distinctive features like purple pigment and waxiness in all plant parts, blackish awns, brown spikes with hairy glumes	6.80

*Figures in parentheses are yields under rainfed conditions.
Source: Directorate of Research, CSKHPKV Palampur and Field Survey (adoption rate)

Table 4. Desirable traits of new varieties, multiple responses of farmers

Particulars	Multiple rank score (No.)					Composite index
	0	1	2	3	4	
High yielding				15	35	3.70
High straw yield			3	17	30	3.54
Disease resistance			5	22	23	3.36
Lodging resistance			16	26	8	2.84
More input responsive			3	30	17	3.28
Early maturity	12		4	18	16	2.52
Less shattering losses		15	5	10	20	2.70
Easy threshing		20	5	10	15	2.40
Good flour quality	15			15	20	2.50
Bold grain				32	18	3.36

0- Same as existing, 1-Fair, 2-Good, 3-Very good, 4- Excellent
Source: Field survey 2008-09

Impact assessment of wheat technology

The data show that newly released varieties viz., HPW-184 and HPW-155 have performed quite well on farmers' fields. As shown in table 5, under irrigated conditions these varieties gave significantly higher yield (34.74 q/ha) as compared to the commonly grown varieties (29.91q/ha). Even under unirrigated conditions, the comparative yields were 16.71q/ha and 14.41q/ha, respectively. Thus, the new varieties gave additional yield over existing varieties to the extent of 4.83 q/ha and 2.30 q/ha under irrigated and rainfed conditions, respectively.

The comparative input use pattern in common varieties and improved varieties of wheat has been depicted in table 6.

Table 5. Yield of HPW 184/HPW 155 vis-à-vis other varieties

Variety	Irrigated	Unirrigated
HPW 184/HPW 155	34.74	16.71
Other varieties	29.91	14.41
Mean difference	4.83*	2.30*
Standard error	1.5475	1.1042

*Significant at 5 percent level of probability
Source: Field survey, 2008-09

Table 6. Mean levels of input use in common and improved varieties of wheat (per ha)

Particulars	Common	Improved	Difference (%)
Seeds(kg)	147.82	124.08	-13.74
FYM (q)	105.50	117.74	12.24
Fertilizers (NPK, kg)	128.58	149.52	20.94
Plant protection chemicals(Rs.)	152.32	128.86	-23.46
Irrigation (No.)	1.24	1.36	0.12
Human labour (mandays)	49.85	49.44	-0.41
Bullock labour(pairdays)	9.92	11.40	1.48
Machine (hrs.)	0.90	1.32	0.42

Source: Field survey, 2008-09

The seed rate was lower in improved varieties as compared to common/local varieties which may be due to awareness about recommended seed rate. The use of FYM was about 117 q/ha in improved variety as compared to 105 q/ha in local variety. Higher use of fertilizers (NPK) was found in improved varieties (about 150 kg/ha) in comparison to other common varieties. However, lack of knowledge about balanced use of nutrients and lower cost of urea contributed to more use of N in comparison to P and K nutrients. The use of plant protection measures and weedicides was quite low in wheat crop and the farmers purchasing seed from the Department of Agriculture or KVKs were getting treated seeds. Thus, better package of practices were followed in case of improved varieties clearly showing the effect of advice from extension agencies.

The input-output relationship in case of improved varieties and common varieties has been depicted in table 7. The pooled analysis of improved and common varieties clearly shows that the improved varieties have more yield potential. This is evident from significant value of the dummy variable. The improved varieties showed genetic superiority and better response to inputs. The intercept value for improved variety came out to be 4.82 quintals in comparison to 3.03 quintals for local variety. Further, while the variables like NPK fertilizers and irrigation were found to be the major limiting factors in wheat production, human labour did not show any significant effect. The robustness of the regression equation was evident from significantly higher value of R^2 which shows that the variables under consideration explained reasonable variations in yield of wheat. The decomposition of technical change in wheat production is depicted in Table 8. This is amply clear that as a result of adoption of new variety, the farmers got 3.01 quintal additional yield than the local variety while about 1.50 q/ha increase in yield was attributed to increase in the use of inputs. Overall, the total increase in the yield was estimated to be 17.25% over the local varieties, out of which 11.50% was solely on account of new variety and the remaining 5.75 % was because of more use of inputs in new variety.

Table 7. Input-output (q) relationship and technical efficiency

Particulars	Regression coefficients		
	Pooled	Common varieties	Improved varieties
Intercept	4.0416	3.0284	4.8198
Farm yard manure (q)	0.0317	0.0788	0.0365
	(0.0217)	(0.0466)	(0.0267)
Fertiliser (NPK kg)	0.0569*	0.0615*	0.0851*
	(0.0273)	(0.0323)	(0.0392)
Irrigation (No.)	5.5219**	4.4571**	5.9054**
	(0.9592)	(2.4248)	(1.2679)
Human labour (days)	0.0674	0.0171	0.0303
	(0.0731)	(0.1439)	(0.0848)
Dummy for new variety	4.7758*		
	(2.0535)		
R^2	0.64807	0.8255	0.5656
F-value	25.0438	23.6468	14.3212
Degrees of freedom	68	20	44

*Significant at 1% level
** Significant at 5% level
Figures in parentheses show standard errors of coefficients

Table 8. Decomposition of technical change in wheat production

Components of change	Quantity (q/ha)	Percent
Change due to new variety	3.0120	11.50
Change due to inputs	1.5065	5.75
FYM	0.4463	1.70
Fertilizers	1.7815	6.79
Irrigation	-0.7087	-2.70
Human labour	-0.0126	-0.05
Total change in output	4.5186	17.25

The elasticity of production was significantly high in respect of fertilizers and irrigation in case of improved varieties indicating better resource-use efficiency with respect to these inputs (Table 9). The resource use efficiency is further examined through marginal products realized through the application of different inputs and also through MVP factor price ratio. In case of improved variety, 1 kg of NPK fertilizer added about 8.5 kg of wheat to the total output. The ratio clearly reveals that 1 Re spent on fertilizer added about Rs. 11.28 worth of output. Likewise, an additional irrigation would increase the yield of wheat by about 5.91 quintals/ha indicating a high ratio of around 12.92. The contribution of FYM and human labour was low and reveal low MVP factor price ratio. In case of common/local variety, the resource use efficiency exhibited similar pattern though less in magnitude. The higher elasticity and MVP factor price ratios with respect to improved variety clearly indicate the technical superiority and economic viability of newly released varieties of wheat.

Table 9. Resource use efficiency in improved and local varieties of wheat

Inputs	Elasticity of production	Marginal/ incremental output (kg) per unit input	Additional returns per rupee invested
Improved varieties			
FYM (q)	0.1399	3.64	0.77
Fertilizer (kg)	0.4147	8.51	11.28
Irrigation (No.)	0.2387	590.54	10.34
Human labour (mandays)	0.0488	3.03	0.26
Common varieties			
FYM (q)	0.3178	7.88	1.66
Fertilizer (kg)	0.3022	6.15	8.15
Irrigation (No.)	0.2317	445.70	7.79
Human labour (mandays)	0.0326	1.71	0.15

Economics of improved and common/ local varieties

The economics clearly supports the adoption of improved varieties of wheat due to higher yield (Table 10). Total cost of cultivation per hectare though was higher in improved variety but due to additional yield cost per quintal decreased from Rs. 756 to Rs. 698/q with the input cost saving of about Rs. 57 per quintal of produce. The improved varieties yielded additional gross and net returns of Rs. 4117/ha and Rs. 2549/ha over the common/local varieties. Based upon the quantity of seed of HPW-155 and HPW-184 distributed in the state, the total area under the new variety in mid hill zone of H.P was estimated 22,173 ha with additional output of more than 72,000 quintals which is clearly the contribution of new varieties (Table 11). The

Table 10. Variable and fixed cost in local and improved varieties of wheat (Rs./ha)

Particulars	Common varieties	Improved varieties	Difference
Fixed cost			
Rental value of land	4800	5250	450
Depreciation of tools and equipments	800	950	150
Interest on fixed capital	400	425	25
Land revenue	50	50	-
Total fixed cost	6050	6675	625
Variable cost			
Seed	1774	1985	211
FYM	5275	5887	612
Fertilizers	964	1121	157
Plant protection	152	129	-23
Human labour	5982	5933	-49
Bullock labour	2976	3420	444
Machinery power	360	528	168
Sub-total	17484	19003	1520
Interest on working capital	437	475	38
Total variable cost	17921	19478	1557
Total cost	23971	26153	2182
Cost per quintal*	755.61	698.14	-57.47
Returns			
Gross returns	34097	38213	4116
Net returns over total cost	10126	12060	1934
Net returns over variable cost	16176	18735	2559

* after excluding value of wheat straw from total cost
Source: Field survey, 2008-09

Table 11. Area and additional output of new varieties

Year	Area under new varieties (ha)*	Additional output (q)
2003-04	3696	12084
2004-05	7391	24169
2005-06	11087	36253
2006-07	14782	48338
2007-08	18478	60422
2008-09	22173	72507

* based upon quantity of seed distributed; Source : Field survey, 2008-09

impact would have been much more discernible had the state agencies multiplied and distributed more quantity of seed of these varieties.

The overall return to R&D investment has been estimated and given in table 12. The table shows that since 2003-04 the new varieties have produced net incremental benefits worth Rs. 690.66 Lakh with the additional investment of just Rs.365 Lakh on R&D (AICWIP) over the period of last 8 years. The net present value of benefits came out to be Rs. 352.30 Lakh. The benefit cost ratio came out to be

Table 12. Returns to R & D expenditure (Rs in lakhs)

Year	Seed distribution cost	Added cost incurred by farmers	R & D expenditure (AICWIP)	Total additional cost	Incremental gross benefits	Net incrementa benefits
2000-01			31.19	31.19	0.00	-31.19
2001-02			31.19	31.19	0.00	-31.19
2002-03			41.06	41.06	0.00	-41.06
2003-04	18.49	57.60	41.06	117.15	91.28	-25.87
2004-05	36.96	115.15	42.15	194.26	190.93	-3.33
2005-06	55.43	172.73	41.44	269.60	304.53	34.93
2006-07	73.91	230.31	42.44	346.66	435.04	88.38
2007-08	92.39	287.88	46.37	426.64	725.07	298.43
2008-09	110.87	345.46	48.44	504.77	906.33	401.56
Grand Total	388.05	1209.13	365.34	1962.52	2653.18	690.66
Net worth of benefits		352.30				
Benefit cost ratio		1.28				
Internal rate of returns over R & D investment on wheat varieties		36.75%				

Source: Field survey, 2008-09

1.28 with high internal rate of return (36.75%). Besides economic benefits, the wheat research programme of the university has helped in maintaining rich repository of rust resistant lines thereby protecting the spread of rust diseases in the plains too. These lines are used by the breeders across the countries as a source of incorporating resistance in improved wheat varieties.

Constraints and strategies for increasing wheat production

Hill agriculture is practiced under tough conditions because of its unique characteristics such as topographical features and climatic variations along the gradient. Small and scattered land holdings are the main features of hill agriculture. These biophysical and socio-economic constraints result in low technical efficiency as well as discourage farmers to bear risk.

Lack of irrigation is the most limiting factor in wheat production in Himachal Pradesh. Around 81 to 82 per cent of the wheat area is rainfed. In some of the districts like Hamirpur, Shimla and Bilaspur less than 10 per cent of the area is irrigated. The rabi rainfall pattern in different districts has been quite erratic especially in the recent years. In wheat sowing months (November & December), no or very low rainfall was recorded in some of the years. The maximum rainfall (609mm) was recorded in the year 1997-98 while the minimum rainfall (246mm) was recorded in the year 2000-01 which was the severe drought year in the state. Yet another important constraint is the faulty seed chain and distribution. The seed production chain in the state is beset with structural problems. University is producing breeder seed of different varieties but further multiplication at the

state level is not adequate. The seed multiplication farms are producing meager quantity of seeds of new varieties of wheat. Resultantly, seeds of new varieties are not reaching the farmers resulting into poor adoption rate and slow transfer of technology. The low adoption of package of improved practices is also an important constraint in increasing production. Farmers do not lay much emphasis on improved cultural practices. In fact, wheat is regarded as a labour saving crop by the farmers. No farmer was using line sowing. The intercultural operations also include mostly manual removal of weeds from standing crop. The use of pesticides /herbicides was almost negligible. However, top dressing of urea was quite familiar among the farmers.

Based upon the constraints analysis, both short term and long term strategies need to be formulated to increase productivity and production of wheat in the state. The short term measures can be taken up immediately to address supply side constraints like strengthening seed multiplication chain, improving input delivery particularly improved seeds and fertilizers, quality checks and proper quarantine measures on seeds and critical inputs, encouraging seed treatment and extension awareness campaign for better adoption of improved package of practices. The long term strategies include creating additional irrigation facilities through water harvesting and improving water use efficiency in wheat crop, allocating more funds under AICWIP to strengthen research and development of wheat technology, strengthening state seed multiplication farms and extension for transfer of technology and controlling animal menace including monkey menace.

Conclusions

Wheat is the most important cereal crop of Himachal Pradesh commanding maximum cropped area among all the crops grown in the state. Wheat research has remained the primary mandate of CSKHPKV since its inception and the university has developed number of rust resistant varieties to protect the state and plain areas of the country from the spread of rust diseases. The university has recently developed two promising varieties HPW-184 and HPW-155. The improved varieties not only gave higher yield over common varieties under both irrigated and unirrigated conditions but were also found fairly resistant to yellow rust, Karnal and hill bunt. Overall, the returns on R&D expenditure came out be Rs. 352.30 Lakh with, benefit cost ratio 1.28 and internal rate of return 36.75%. The adoption rate in mid hills of these two varieties could have been higher had the state agencies multiplied seeds in appropriate quantity. There are number of constraints viz. lack of irrigation, erratic/ deficit rabi season rainfall, inadequate seed distribution mechanism, emergence of biotic and abiotic stresses and poor adoption of

package of practices in wheat crop. Both short term and long term strategies need to be implemented to increase the wheat production in the state.

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