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YIELD GAP ANALYSIS OF OILSEED VARIETY BINASARISHA-9 IN SOME SELECTED AREAS OF BANGLADESH

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Abstract

This study was conducted to analyze the yield gap of Binasarisha-9 producing farmers in Rangpur, Mymensingh, Sherpur, Gopalganj and Sunamganj districts of Bangladesh. Primary data were collected from 200 Binasarisha-9 producing farmers through pre-designed interview schedule during April-May, 2021 for achieving the purposes. Descriptive statistical techniques as well as Zandstra method and Cobb-Douglas production function were chosen to determine the yield gap and factors affecting yield of Binasarisha-9 production. The results showed that the estimated average yield gap-I was 0.07 t ha^{-1} (4.11 %) and average yield gap-II was 0.18 t ha^{-1} (12.35 %.). The lowest gap was observed in Mymensingh district (0.19 t ha^{-1} (12.22%) and it was the highest in Gopalganj district (0.31 t ha^{-1} (19.98%). The average total yield gap was 0.25 t ha^{-1} (16.47%) and there was much scope for yield enhancement in the variety. Most of the factors namely, human labour cost, power tiller cost, seed cost, fertilizer cost, irrigation cost and insecticides cost were statistically significant and positive. The yield gap is mainly caused by biological, socio-economic, climate and institutional/policy related factors. Different strategies, such as integrated crop management (1CM) practices, timely supply of inputs including credit to farmers, research and extension collaboration to transfer the new technologies have been discussed as strategies to minimize yield gap. Suggestions have been made to make credit available to farmers to buy necessary inputs. Reducing transaction cost, simplifying lending procedures and strengthening monitoring mechanism of the present credit system are, however, essential to enable the farmers to benefit the credit facility. Efforts should be made to update farmers' knowledge on the causes of yield gap in Binasarisha-9 and measures to narrow the gap through training, demonstrations, field visits and monitoring by extension agencies to achieve high yield.

Key words: Yield Gap, Binasarisha-9, Factors affecting, Cobb-Douglas production function

Introduction

Mustard or rapeseed (*Brassica spp*. L.) is a worldwide cultivated thermo and photosensitive oilseed crop. Asia produces 41.50% of mustard seed which occupies the first position in terms of percentage share of production followed by the USA (FAOSTAT, 2018). Oilseeds were cultivated in less than 2.20% of total arable land under rice-based cultivation system in Bangladesh, where three fourth of total cultivable land was engaged in rice production during 2015-16 (BBS, 2019).

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Bangladesh has to import a noticeable amount of edible oil and oilseeds to meet up the existing accelerating demand. The value of imported oilseed and edible oil has increased dramatically from USD 544 million in 2002-03 to USD 2371 million in 2018-19 which were 4.99 and 4.2 % of the total value of imports respectively (Bangladesh Bank, 2020). Climate change has affected the production of mustard due to an increase in temperature as it has to be sown from mid-October to mid-November and harvested from late January to mid-February. The sowing time has a great impact on the production of rapeseed or mustard. The production of mustard is prone to decrease in India due to changes in sowing time (Ghosh and Chatterjee, 1988; Boomiraj *et al.*, 2010).

Mustard is a cold loving rabi crop grows during October-February usually under rainfed and low input condition in Bangladesh. 'Binasarisha-9' is one of the most important mustard crops in Bangladesh which plays a major role in supplementing the income of small and marginal farmers. Maximum seed yield of Binasarisha-9 is 2.0 tones/ha which is higher than national average. Other improved characters are shorter plant height and black seed coat color. Each kg of Binasarisha-9 yields 430g of mustard oil which is 10% higher compared to other local varieties. Farmers prefer this variety because it's short duration (80-84 days).

The concept of yield gaps in crops originated from different constraint studies carried out by International Rice Research Institute (IRRI) during the seventies. The yield gap comprises at least two components. The first component yield gap-I is the difference between experiment/research station yield and the potential farm yield. This component is not exploitable. The second component of yield gap-II is the difference between the potential farm yield and the actual average farm yield (Alam, 2006). The yield gap-II is exploitable and can be minimized by deploying research and extension approaches and government interventions, especially institutional issues. Yield gaps exist in different crops of Bangladesh such as rice, wheat, potato, oilseeds, pulses, etc. that may range from 19% to about 64% of the potential yield (Alam, 2006; OFRD, 2003-2004 & 2008-2009; Roy, 1997; Matin *et al.*, 1996). The existence of yield gaps was also observed in rice, mustard and cotton in India (Aggarwal, 2008). In India, yield gap varied from 15.5 to 60% with the national average gap of 52.3% in the irrigated ecosystem (Siddiq, 2000). At Atgharia *Upazila* of Pabna district evaluation of the yield gap in mustard using the variety, BARI Sharisha-13 showed yield gap of 35% (OFRD, 2008-2009).

There is a gap between the achievable yield and farmer's actual yield. It is widely perceived that there is a wide gap between the potential and farm level yield and the major part of the gap is due to the yield loss caused by several biotic and abiotic factors (Alam and Hossain, 1998). Timely sowing, irrigation, weeding, plant protection, and timely harvesting could account for more than 20% yield increase (Siddiq, 2000). However, the factors behind this yield gap are yet to be identified. Yield gaps in different crops are the big challenges. Understanding of yield gaps helps inform predictions of future crop yields and targeting efforts to increase sustainable crop production. In addition, information on yield gap also helps government/policymakers develop guidelines or action plans to address the problem of enhancing crop production. Therefore, the study was conducted to estimate the yield gap of Binasarisha-9 growers; to identify the factors affecting the yield of the variety and to suggest some policy recommendations mainly to the government or policy makers to develop guidelines or action plans to address the problem.

Materials and Methods

Study area, sample size and sampling technique

This study was conducted in five districts of Bangladesh, viz., Rangpur, Sherpur, Mymensingh, Gopalganj and Sunamganj. A total of 200 farmers were randomly selected as sample size in the study areas, 40 from each District were selected with the help of Department of Agricultural Extension (DAE) personnel for interview. Field investigators under the direct supervision of the researchers, collected field level cross sectional data using pre-tested interview schedule.

Method of data collection and period of study

Data were collected from sampled Binasarisha-9 producers through face to face interview method using the interview schedule mentioned, above during April-May, 2021.

Analytical techniques

Collected data were edited, summarized, tabulated and analyzed to fulfill the objectives of the study. The data were analyzed with the help of suitable statistical measures like frequencies, percentages, mean and standard deviation. Descriptive statistics were also used to analyze and compare the socioeconomic characteristics.

In the study, the concept of yield gap as suggested by Zandstra *et al.* (1981) was used. Total yield gap can be decomposed into two parts i.e. Yield gap I and Yield gap II. Yield Gap I refer to the difference between research station's yield and potential farm yield obtained at demonstration plots, while Yield Gap II, reflecting the effects of biophysical and socio-economic constraints, was the difference between yield obtained at the nearest potential plot and actual yield obtained on farmers' fields.

The yield gaps were estimated as follows:

$$\text{Yield Gap I} = [(Y_R - Y_P)/Y_R] \times 100$$

$$\text{Yield Gap II} = [(Y_P - Y_F)/Y_P] \times 100$$

Where,

Y_R is the research station yield,
Y_P is the potential farm yield, and
Y_F is the actual farm/farmers yield

Statistical Analysis

The production of Binasarisha-9 is likely to be influenced by different factors, such as, seed, chemical fertilizer, etc. The following Cobb-Douglas type production function was used to estimate the parameters. The functional form of the Cobb- Douglas multiple regression equation was as follows:

$$Y = AX_1^{b1} X_2^{b2} \ldots\ldots\ldots\ldots\ldots\ldots X_n^{bn} e^{ui}$$

The production function was converted to logarithmic form so that it could be solved by least square method i.e.

$$\ln Y = a + b_1 \ln X_1 + \ldots\ldots\ldots\ldots\ldots\ldots\ldots + b_n \ln X_n + e^{ui}$$

The empirical production function was the following:

$$\ln Y = a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + b_7 \ln X_7 + b_8 \ln X_8 + Ui$$

Where,

Y = Yield/Gross return (Kg ha^{-1})
X_1 = Power tiller (t ha^{-1})
X_2 = Human labor (Man days ha^{-1})
X_3 = Seed (kg ha^{-1})
X_4 = Fertilizer (Kg ha^{-1})
X_5 = No. of Irrigation
X_6 = No. of Weeding
X_7 = Insecticide
X_8 = Soil fertility

a = Constant value
b_1 b_2 .... b_8 = Co-efficient of the respective variables and
U_i = Error term.

Results and Discussion

The results showed that the highest yield in farmers level was obtained in Mymensingh (1.41 t ha^{-1}) followed by Sunamganj (1.38 t ha^{-1}), Rangpur (1.36 t ha^{-1}), Sherpur (1.30 t ha^{-1}) and Gopalganj (1.29 t ha^{-1}) districts. The average yield of Binasarisha-9 was 1.35 t ha^{-1} (Table 1). The estimated average yield gap-I was 0.07 t ha^{-1} (4.11 %) and average yield gap-II was 0.18 t ha^{-1} (12.35%.). The lowest gap was 0.19 t ha^{-1} (12.22%) observed in Mymensingh district and it was the highest 0.31 t ha^{-1} (19.98%) in Gopalganj district. Considering all areas, the average total yield gap was 0.25 t ha^{-1} (16.47%) and there was much scope for yield enhancement in the variety (Fig. 1).

Table 1. Estimated yield gap of Binasarisha-9 in different areas

Particular	Rangpur	Mymensingh	Sherpur	Gopalganj	Sunamganj	Average
Average research station yield (Y_R), t ha^{-1}	1.65	1.60	1.55	1.60	1.62	1.60
Average potential farmers yield (Y_P), t ha^{-1}	1.58	1.50	1.48	1.54	1.56	1.53
Average actual farm yield (Y_F), t ha^{-1}	1.36	1.41	1.30	1.29	1.38	1.35
Yield gap I (%)	0.07 (4.24)	0.10 (4.38)	0.07 (4.52)	0.06 (3.75)	0.06 (3.70)	0.07 (4.11)
Yield gap II (%)	0.22 (13.92)	0.09 (7.84)	0.18 (12.16)	0.25 (16.23)	0.18 (11.54)	0.18 (12.35)
Total yield gap (%)	0.29 (18.17)	0.19 (12.22)	0.25 (16.68)	0.31 (19.98)	0.24 (15.24)	0.25 (16.47)

Source: Field survey (2021)

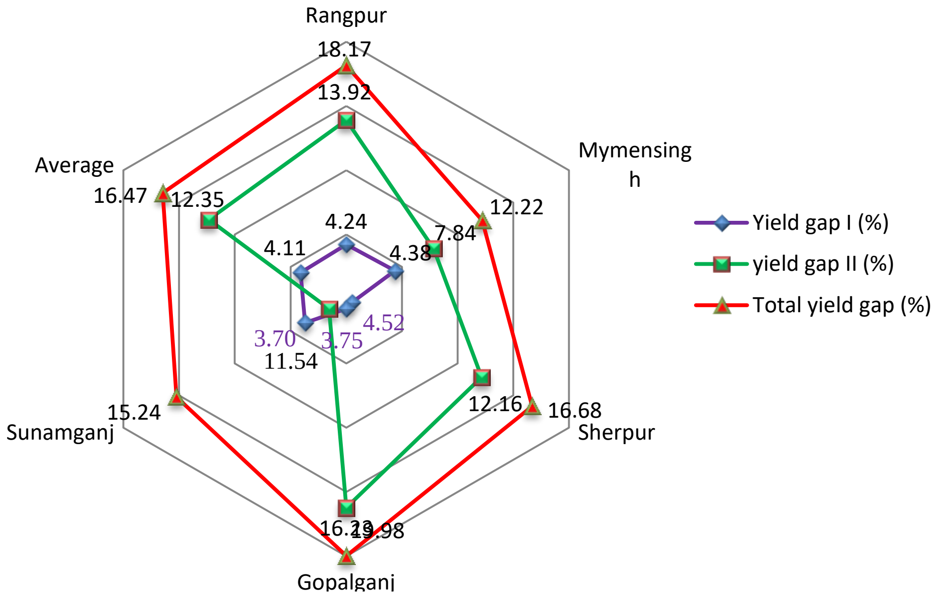

Figure. 1. Yield gap (%) of Binasarisha-9 in different districts of Bangladesh

Major factors that influencing the yield of Binasarisha-9

Major factors influencing the yield of Binasarisha-9 were described in Table 2. The district- wise farmers have to maintain the recommended dose to some extent but in average. The farmers in the study areas did not use the recommended doses of seed rate and fertilizers. The average seed rate was 8.33 kg ha^{-1}, Urea 202.86 kg ha^{-1}, TSP 163.52 kg ha^{-1}, MoP 102.69 kg ha^{-1}, Zypsum 130.56 kg ha^{-1} and ZnSO4 7.38 kg ha^{-1} respectively, indicating that they are either below or above the recommendation.

Table 2. Input–use pattern of Binasarisha-9 growing farmers

Factors	Seed (kg ha^{-1})	Urea (kg ha^{-1})	TSP (kg ha^{-1})	MoP (kg ha^{-1})	Zypsum (kg ha^{-1})	$ZnSO_4$ (kg ha^{-1})
Recommendation	6.92-7.41	198-222	173-198	111-136	124-148	9.88
Rangpur	8.34	210.32	161.48	105.68	136.56	7.25
Mymensingh	7.98	187.14	165.35	112.92	142.39	8.94
Sherpur	8.67	232.58	175.23	98.97	120.95	6.45
Gopalganj	8.21	165.95	155.22	101.64	124.28	6.89
Sunamganj	8.45	218.33	160.31	94.25	128.61	7.36
Average	8.33	202.86	163.52	102.69	130.56	7.38

Source: Field survey (2021)

Other factors which were also responsible in the yield of Binasarisha-9 are described in Table 3. On average, 68% farmers used power tiller more than two times, 57% farmers irrigated their lands 1-2 times, 62% farmers did not do weeding to their lands and 61% farmers spray pesticide and insecticide to control disease and insect.

Table 3. Input–use pattern of Binasarisha-9 growing areas

Factors	Rangpur	Mymensingh	Sherpur	Gopalganj	Sunamganj	Average
Power tiller (%)						
One times	3	2	-	-	5	3
Two times	17	30	27	35	40	29
More than 2	80	68	73	65	55	68
Irrigation (%)						
No irrigation	47	41	55	38	35	43
Irrigation (1-2)	53	59	45	62	65	57
Weeding (%)						
No weeding	65	70	58	54	62	62
Weeding 1	35	30	42	46	38	38
Pesticide & insecticide (%)	78	82	57	42	48	61

Source: Field survey (2021)

To determine the effects of the explanatory variables, linear and Cobb-Douglas model were initially estimated for Binasarisha-9 production. Some of the key variables are explained below.

The contribution of specified factors affecting production of Binasarisha-9 could be seen from the estimation of regression equation. It can be seen from Table 4 that most of the parameters are statistically significant and positive. Very few farmers used Boric Acid and manure, so this was not included in the equation. The result showed that few coefficients do not have the expected sign.

The regression coefficients for power tiller and human labor for Binasarisha-9 under all areas were positive and significant at 1% level. On the other hand, coefficients for seed, fertilizer and insecticides were found to be positive and significant at 5% level and coefficient of irrigation was positive and significant at 10% level under all areas.

The regression coefficient of weeding for Binasarisha-9 under all areas was positive but not significant. On the other hand, the coefficient of soil fertility was negative but significant under all areas.

The positive sign indicated that using more of these inputs in Binasarisha-9 production could increase the yield to some extent. The negative sign of soil fertility indicate that yield was not achieved according to the fertility.

Coefficient of multiple determination (R^2)

The coefficient of multiple determination (R^2) tells how well the sample regression line fits the data. It is evident from Table 4 that the values of R^2 were 0.732, 0.791, 0.771, 0.810 and 0.845 for Rangpur, Mymensingh, Sherpur, Gopalganj and Sunamagnj districts, respectively. This means that around 73, 79, 77, 81 and 84 percent of the variations in gross return for Binasarisha-9, respectively were explained by the independent variables included in the model. The value of R^2 under all areas was 0.810 means that 81percent of the variations in gross return was explained by the independent variables included in the model.

F-value

The F-values of Rangpur, Mymensingh, Sherpur, Gopalganj and Sunamagnj districts were 8.810, 9.767, 8.936, 10.611 and 11.431 which were highly significant at 1% level of probability implying that all the explanatory variables were important for explaining the variations in gross returns of the Binasarisha-9 variety in the study area (Table 4). The F-values of all areas were 10.218 which was highly significant at 1% level of probability implying that all the explanatory variables were important for explaining the variations in gross returns of the Binasarisha-9.

Return to Scale

The summation of all the production coefficient indicates return to scale. The sum of elasticity coefficients were 1.018, 1.066, 1.028, 1.086 and 1.024 in case of Binasarisha-9 meaning increasing returns to scale (Table 4). This means that, 1 percent increase in all inputs simultaneously would result on average 1.018, 1.066, 1.028, 1.086 and 1.024 percent increase in gross return of Binasarisha-9. The elasticity coefficients under all areas was 1.049 means that 1 percent increase in all inputs simultaneously would result on average 1.049 percent increase in gross return of Binasarisha-9 in the study areas. This value being greater than 1 means that the farmers are operating at the region of increasing return to scale. More clearly, the farmers still have the scope to allocate more inputs in their mustard field as it will generate a higher return than production cost.

Table 4. Estimated values of regression co-efficient and related statistics of Cobb-Douglas production function for Binasarisha-9 production

Explanatory variables	Study areas										All areas	
	Rangpur		Mymensingh		Sherpur		Gopalganj		Sunamganj			
	Co-efficient	SE	Co-efficient	SE	Co-efficient	SE	Co-efficient	SE	Co-efficient	S.E	Co-efficient	SE
Intercept	2.124***	0.821	3.710***	1.401	4.750***	0.610	4.450***	0.450	4.037***	1.206	3.590***	1.250
Power tiller (X_1)	0.214***	0.011	0.214**	0.085	0.322***	0.086	0.059**	0.516	0.010**	0.011	0.267***	0.078
Human labor (X_2)	0.098***	0.080	0.231**	0.120	0.229**	0.090	0.361***	0.141	0.214***	0.085	0.247***	0.071
Seed (X_3)	0.610*	0.140	0.302*	0.090	0.151**	0.081	0.231*	0.180	0.602**	0.214	0.182**	0.121
Fertilizer (X_4)	0.237*	0.066	0.231	0.091	0.215	0.081	0.281*	0.130	0.054	0.130	0.420**	0.161
Irrigation (X_5)	0.021*	0.300	0.051*	0.040	0.088**	0.076	0.079*	0.132	0.440*	0.318	0.056*	0.610
Weeding (X_6)	0.091	0.081	0.281	0.121	0.129	0.090	0.321*	0.241	0.224	0.087	0.241	0.071
Insecticides (X_7)	0.254**	0.118	0.181*	0.126	0.184**	0.162	0.211**	0.128	0.460*	0.161	0.312**	0.181
Soil fertility (X_8)	0.074*	0.851	0.210	0.020	-0.271**	0.090	-0.161*	0.090	-0.121**	0.101	-0.281**	0.086
Coefficient of multiple determination (R^2)	0.732		0.791		0.771		0.810		0.845		0.810	
F-value	8.810***		9.767***		8.936***		10.611***		11.431***		10.218***	
Returns to scale	1.018		1.066		1.028		1.086		1.024		1.049	

Source: Field survey (2021)
Note: *** Significant at 1% level, ** Significant at 5% level, * Significant at 10% level (SE = Standard Errors)

Factors Causing Yield Gap in Binasarisha-9

Several factors can cause yield gap in Binasarisha-9 production. In general, factors causing yield gaps can be classified as follows (RAP, 1999):

Biological factors

Variety, soil fertility, management practices (fertilizer, water, pest management, etc.).

Socio-economic factors

Social and economic status of farmers, family size, farm holding, knowledge and education level of farmers, contact with extension agents.

Climatic factors

Flood, drought, salinity, etc. caused by climatic changes.

Institutional/government policy related factors

Input/output price, availability of inputs, credit supply, tenancy, etc. The price of produces and fertilizers could influence the rate of fertilizer use by farmers and thereby yield.

Factors promoting technology transfer

Research-extension linkage, training of extension personnel on the new technology, their knowledge and education level about the technology, demonstration of the technology, field visits and monitoring, etc. by extension.

Constraints of Binasarisha-9 cultivation

Farmers faced various constraints to Binasarisha-9 cultivation in the study areas. In Table 5, about 88% farmers opined inadequate supply of quality seeds as a top ranked constraint of Binasarisha-9 cultivation. Other constraints were rainfall during harvesting time (45%), lack of credit facilities (41%), lack of training on oilseed cultivation (38%), infestation of insects (32%) and natural calamities (16%).

Table 5. Major constraints of Binasarisha-9 cultivation.

Sl. No.	Constraints	Percent of farmers responded						Rank
		Rangpur	Mymensingh	Sherpur	Gopalganj	Sunamganj	All areas	
1.	Inadequate supply of quality seeds	95	98	80	75	96	88	1
2.	Rainfall during harvesting time	37	40	55	45	52	45	2
3.	Lack of credit facilities	30	82	8	28	59	41	3
4.	Lack of training on oilseed cultivation	30	25	53	15	71	38	4
5.	Infestation of insects	17	13	12	80	42	32	5
6.	Natural calamities	21	13	8	18	22	16	6

Source: Field survey (2021)

Some policy guidelines to reduce the Yield Gap

Policies to reduce the yield gap, such as integrated crop management (ICM) practices, timely supply of inputs including seed and credit to farmers, research and extension collaboration to transfer the new technologies would be the strategies to minimize yield gaps. Necessary steps should be taken to make credit available to resource-poor small farmers to buy necessary inputs. Government should take appropriate action through law enforcing agencies to stop the use of adulterated fertilizer and insecticide throughout the country. Reducing transaction cost, simplifying lending procedures and strengthening monitoring mechanism of the current credit system are, however, essential to enable the farmers to avail the credit facility. Efforts should be made to update farmers' knowledge on the causes of yield gaps in mustard crops and measures to narrow the gaps through awareness, motivation, training, demonstrations, field visits and monitoring by extension agencies to achieve high yield.

Conclusion

In the study areas, the average total yield gap was 0.25 t ha^{-1} (16.47%). That means we are losing 0.25 t ha^{-1} yield of Binasarisha-9 in Rabi season. It is essential to promote collaboration among research, extension, NGOs and private sector to develop appropriate technologies with a view to narrowing yield gaps. If we could reduce yield gaps with these steps, our mustard production per year will be increased and farmers as well as the country will be benefitted. All of the factors namely, power tiller, human labour, seed, fertilizer, irrigation and insecticides are very important for Binasarisha-9 cultivation. There is a need of proper guide to farmers about Binasarisha-9 production management practices in the study areas.

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