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Yield Gap Analysis of TBG-104 (Blackgram variety) in Southern Zone of Andhra Pradesh

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A B S T R A C T

Yield gap analysis is an increasingly popular concept in agriculture sector. It is always a matter of concern for the research managers, agriculture scientists and development administrators to ensure that the real potential of any crop variety is harvested at the farmers' field. Further, contributing factors for the yield gap is also very important to manage the higher yields positively. In this study, Yellow mosaic resistant, TBG-104, a new variety of blackgram is considered which showed a higher yield gap between potential yield given by the breeder and the actual yield realized in the farmers' fields during *rabi* season. Surprisingly, on an average 1.5 folds more yield is observed in the famers' fields. A random sample of fifty-two farmers who cultivate TBG-104 was selected from three districts of Southern Zone of Andhra Pradesh and their fields are monitored from sowing to harvesting and data is collected on six factors. Out of six factors, two factors viz., *two micronutrient sprays along with pesticide application* at recommended level (MN_2) and providing *supplement irrigation* in crucial stages of the crop have been identified as significant contributors in realizing higher yields of the variety. From the regression model it is noticed that the average yield of this variety is 4.9quintals per acre irrespective of other management practices if pest is not infected. By providing supplement irrigation, nearly 1.5 quintals per acre can be protected while 2.7 quintals per acre can be protected with the application of two sprays of micronutrients and usage of pesticides. Hence, this variety can achieve its potentiality in congenial environment with scrupulous crop management i.e. application of nutrients and insect control and providing supplemental irrigation at crucial stages of crop growth.

Introduction

The concept of yield gap is one of the important challenges faced in the Agricultural Sector. However, a gap always prevails between what is projected as the potential yield of any variety at research station and what is obtained in organized farm trials and further what is harvested by the farmers themselves. Technically, this is referred as yield gap, which are of different types. It is a powerful method to reveal and understand the biophysical opportunities to meet the projected increase in demand for agricultural products towards 2050 and to support decision making on research, policies,

development and investment also. There are number of empirical evidences pertaining to yield gap analysis in agricultural crop like wheat, cotton, rice etc. (Aggrawal *et al.,* 2008). Kiresur *et al.,* (2001) analysed profitability and Girish Kumar Jha *et al.,* (2012) worked on sustainability of improved oilseeds production technologies for eight oilseeds crops. This study also helps to improve the efficiency of land and labour use, reduce production cost and increase food security.

It is also an important aspect to be considered by the scientists and administrators as the post follow-up action after releasing any variety whether the actual potentiality of that variety is being realised by the farmers with the suitable managing practices or not. At this juncture, a typical study is planned with the objectives includes to identify the major crop variety which has more yield gap. To explore the significant factors for the yield gap. And also to provide suggestions in retrieving the yields at its potential level.

Singh *et al.,* (2007) described two types of yield gap in terms of technological and extension yield gaps using frontline demonstrations data (FLD) on mustard. He observed that there was a positive impact of FLD over existing practices for farming community of Lucknow districts. They were motivated by the new agricultural technologies applied in the FLD plots. Mattigatti *et al.,* (2009) analysed and classified the total yield gap in sericulture into three types of yield gaps namely yield gap-I, yield gap-II and yield gap-III. Yield gap-III indicates the yield uncertainty in sericulture. Yield gap-I (33.40%), is found maximum compared to others due to variation in natural resources. Most of the farmers have taken up the latest mulberry variety and silkworm hybrids realized a low yield gap-II in the study area. There was significant difference among the reasonable, predictable and the actual yield of mulberry. In Gujarat, groundnut and sesame are the two major crops of Saurashtra region, known as "Peanut Bowl" of India. Dhandhalya *et al.,* (2009) measured two types of yield gap in their study. The analysis revealed that a wide yield gap exists in major oilseed crops of study region. The loss in production in both crops was mainly due to biotic, abiotic and socio-economic constraints. Thus, there is a growing need for evaluation of agricultural research investment and setting priorities for research investment. Choudhary *et al.,* (2009) discussed technology and extension yield gaps in the context of oilseeds. The extensive research has done by Billore *et al.,* (2009) revealed that the highest soybean yield (2705 kg/ha) could be achieved with improved technology. This fact has earlier been reported in the literature stating that the improved package of practices which followed in the national demonstrations for various crops has shown high yield potentials. Interestingly, over the years farmers' practice fetched more yield than that of improved technology.

Materials and Methods

Yield gap analysis

The methodology developed by International Rice Research Institute (IRRI) is followed to estimate the magnitude of yield gaps, wherein potential yield, farm yield and farmers' yield are defined as yield obtained at research stations, demonstration plots and farmers' fields, respectively.

$$\text{Yield Gap index I (\%)} = \frac{PY-IV}{PY} X100 \text{ ----(3.1)}$$

$$\text{Yield Gap index II (\%)} = \frac{IV-FV}{IV} X100 \text{ -----(3.2)}$$

$$\text{Yield Gap index III (\%)} = \frac{PY-FV}{PY} X100 \text{ --- (3.3)}$$

where, PY=Potential yield claimed by breeders, IV=Yield at research station, and FV= Yield at farmers field. IV and FV are taken from the Front-Line Demonstrations.

Potential yield for each major crop was taken from the respective breeder, yield at research stations (IV) was taken from the KVK and DAATTCs from their Front-Line Demonstrations in three districts of Southern zone and yield at farmers field (FV) will also be noted.

Multiple linear regression

The model for multiple linear regression, given *n* observations, is

$$Y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \beta_3 x_{i3} + \ldots \beta_p x_{i2p} + \varepsilon_i$$

for   *i=1, 2,.....n*   --------(3.4)

Results and Discussion

Research on Groundnut, Pulses, Sugarcane and Millets is being carried out by the Regional Agricultural Research Station in Southern Zone of Andhra Pradesh. In this study, Groundnut and Pulses varieties released recently from this Station have been considered for the yield gap analysis. Secondary data is collected from the released proposals of the varieties from respective breeders, data is also taken from the performance evaluations done by the extension Stations (KVK/DAATTC) and the real time data from the farmers fields pertaining to the same crop varieties are also recorded. Yield gap indices are computed for highly popular varieties of groundnut and pulses varieties with help of equations (3.1) to (3.3).Among them the highest yield gap is observed for a blackgram variety TBG-104 among all and summarized in table 1.

From table 1, it is noticed that TBG 104 realized very high yield in farmers' fields

whereas its yield is low in almost all experiments in Research and Extension trials during three successive years from its release. It might be due to type of soil, favorable conditions of weather and very good pest management practices. Hence, TBG-104 is considered for the current study to work upon the second objective i.e. to identity the key factors for the yield gap (Fig. 1 and 2).

TBG104, a blackgram variety -at a glance

In Andhra Pradesh, Blackgram is being grown in 5lakh hectares in three regions i.e. in Coastal region under *rabi* and rice fallows, in Telangana region as *kharif* crop and in Rayalaseema under Rabi rainfed and rabi ID since 2005.

Yellow Mosaic Virus (YMV) causes havoc, destroying blackgram sown in hundreds of acres in AP. Most of the high yielding varieties of blackgram grown in Andhra Pradesh such as LBG 623, LBG 645 and LBG 685 are susceptible to Yellow Mosaic Virus (YMV) disease. Farmers switched over to cultivation of Maize under Rice fallows and go for seed guar or Bengal gram in *rabi* rainfed.

The area under this crop decreased with successive losses. Speculation in market prices, rising cost of cultivation, fertilizer and possibility of soil infertility now have cast a shadow on these non-traditional crops. Research work was initiated in 2009 to develop Yellow Mosaic Virus resistant variety in blackgram using PU-19as donor for YMV.TBG104, YMV tolerant line was identified from PU19x LBG623 cross combination in 2014-15 and released under the name of 'Tirupati Minumu-1' in 2016.

Salient characters of TBG 104

Developed using parents PU-19 and LBG623

Tolerant to Yellow Mosaic Virus and photo-insensitive suitable for all seasons (*kharif, rabi* and summer).

Medium duration (75-80 days) with erect plant type.

Shiny black seed of medium in size.

Dark green leaves lanceolate to oval in shape and pods are densely hairy.

Variety developed through marker assisted selection

Yield potential up to 18-20q/ha

Advantages

Popularizing high yielding and disease resistant blackgram line, TBG-104 identified from research work of ANGRAU will be useful to overcome crop shift.

Production and productivity of Blackgram can be increased with coming back of farmers to the cultivation of Blackgram, which is most suited for rice fallows in delta region.

Table.1 Yield gap indices of TBG 104

Performance of II over I During Rabi	Average yield(q/ac) I	Average yield(q/ac) II	Yield gap index (%)	Remarks
Yield Gap index I (%) Extension(II) over Breeder(I)	6.4	3.44	-46.13	46% less over Breeder
Yield Gap index II (%) Farmer (II) over Extension(I)	3.44	8.10	**135.15**	135% high over Extension
Yield Gap index III (%) Farmer(II) over Breeder(I)	6.4	8.10	**26.69**	27% high over Breeder

Table.2 Summary of yield obtained from farmers' field

Impact of type of soil on yield(q/ac)			Impact of Weed management on yield(q/ac)			Impact of seed rate on yield(q/ac)		
Type of soil	Mean	SD	Weed management	Mean	Std. Deviation	seed rate k/ac	Mean	Std. Deviation
Red soil	6.30	2.541	No	6.75	3.304	8 -10	8.33	. 2.410
Black soil	7.83	1.801	Yes	7.22	2.074	14-16	7.61	4.243
Total	7.14	2.253	Total	7.14	2.253	Total	7.14	2.253
Impact of Supplement irrigation on yield(q/ac)			**Impact of MN_2+pesticides on yield(q/ac)**			**Impact of Seed treatment on yield(q/ac)**		
Supplement irrigation	Mean	Std. Deviation	pesticides	Mean	Std. Deviation	Seed treatment	Mean	Std. Deviation
No	5.64	1.690	No	5.20	1.398	No	5.25	1.165
Yes	8.64	1.690	Yes	8.75	1.357	Yes	8.21	2.007
Total	7.14	2.253	Total	7.14	2.253	Total	7.14	2.253

Table.3(a) Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.803	0.645	0.627	1.376
2	0.853	**0.728**	0.7	1.235

Table.3(b) ANOVA

Model		Sum of Squares	df	Mean Square	F	p-value
1	Regression	68.741	1	68.741	36.32**	0.000
	Residual	37.85	20	1.893		
	Total	106.591	21			
2	Regression	77.63	2	38.815	25.46**	0.000
	Residual	28.961	19	1.524		
	Total	106.591	21			

a. Predictors: (Constant), MN_2+pesticides
b. Predictors: (Constant), MN_2+pesticides, Supplement irrigation
c. Dependent Variable: Yield

Table.4 Coefficients

Model	Factors	Unstandardized Coefficients		Standardized Coefficients	t-value	p-value
		B	Std. Error	Beta		
1	(Constant)	5.20	0.43		11.95	0.000
	MN_2+pesticides	3.55	0.58	0.80	6.02	0.000
2	(Constant)	4.89	0.41		11.93**	0.000
	MN2+pesticides	2.71	0.63	0.61	4.29**	0.000
	Supplement irrigation	1.51	0.62	0.34	2.41*	0.026

*significant at 5% level
** significant at 1% level

Fig.1 Performance at research trials

Fig.2 Performance at Farmer's field

Inclusion of this crop in cropping systems will promote soil health and answer to the farming community who are facing severe crop loss due to this disease and finally human health.

Success story of blackgram TBG-104

Developed YMV resistant blackgram culture TBG-104 using biotechnology tools. Its performance is found promising in minikit and farmers expressed satisfaction

Performance of TBG-104 in farmers' fields

Primary data was collected from 52 farmers of TBG104 in three districts of Southern Zone of Andhra Pradesh at their fields. Data pertaining to seven variables viz., type of soil, seed rate, seed treatment, weed management, supplement irrigation, two micronutrient sprays (MN_2) and pesticide application and yields are noted. The range of final yield of TBG 104 is noticed as 5 to 12 quintals per acre. Summary of yield in terms of mean and standard deviation as per the six factors is presented in table 2.

From table 2, it is identified that the average yield in Black soils is observed as 7.83 quintals per acre whereas it is only 6.3 quintals per acre in Red soils. This indicates nearly 24% more yield is observed in Black soils. The impact of seed rate is also observed in that 9% yield enhancement is noticed when the seed rate is 14-16 kgs per acre than that of 8-10 kgs per acre. Similarly, in majority of the fields the impact of seed treatment is also observed in

such a way that 56.4% of yield protection is saved in critical situations. The impact of weed management is noticed as 7%. Finally, it is observed that there is significant impact of supplement irrigation by 53.23% and with the usage of two sprays of micronutrients and pesticides at recommended level nearly 68% of the yield is retrieved significantly.

Yield gap model for TBG 104

Further, a Multiple Linear Regression model is constructed using equation (3.4) on yield with six factors using SPSS-20 (trial version) in stepwise approach to identify the significant factors for the higher yields realized in the farmers' fields. The model summary is given in table 3(a), 3(b) to 4.

Model summary gives details of the overall correlation between the variables left in the models and the dependent variable. With model-2, 70% of variation in the yield can be explained using two independent variables such as MN_2 + pesticides, Supplement irrigation. That means with the introduction of the second variable i.e supplement irrigation the variance is enhanced from 63% to 70% that indicates nearly 7% of the variation in the yield is explained by the variable supplement irrigation. As it is optimally good, we can rely on this model.

The table 3(b) is the F-test for the adequacy of the model. The linear regression's F-test has the null hypothesis that the model explains zero variance in the dependent variable (in other

words $R^2 = 0$). The F-test is highly significant; thus, one can assume that the model explains a significant amount of the variation in the yield. Hence the model is adequate.

Finally, the table 4 shows the regression coefficients that is quantity of contribution from each independent variable towards dependent variable i.e yield. The model can be written as;

Yield = 4.896 +2.714[**] (MN_2+pesticides) + 1.519[*](supplement irrigation)

From the model, it is noticed that the potential yield of this variety is approximately 4.9q/ac irrespective all other management practices. Due to supplement irrigation nearly 1.5 quintals per acre can be protected while 2.7 quintals per acre can be protected with the application of two sprays of micronutrients and usage of pesticides at recommended level.

In conclusion from this study it was found that the major contributors for the yield gap between potential and observed yield of TBG-104 in the farmers' field as two sprays of micronutrients along with pesticide applications at recommended level and supplement irrigation at the time of no rains. Moreover, cultivating TBG-104 in the black soils will further boost up the yield. So, this variety became a boon for the farmers in realizing very good yields and encouraged them to cultivate blackgram in southern zone despite their fear owing to historical failures in blackgram especially due to the Yellow Mosaic Virus.

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