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Yield gap analysis of Niger (*Guizotia abyssinica* L.) in north eastern Ghat zone of Odisha

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Abstract

Niger (*Guizotia abyssinica* L.) is a major oilseed crop grown in Odisha's North Eastern Ghat Zone, but farmers' actual yields is very low as compared to potential yield. During the kharif 2021, Krishi Vigyan Kendra, Kandhamal, in the North Eastern Ghat Zone of Odisha, conducted participatory field demonstrations taking twenty-five farmers in three clusters in the villages of Greenbadi, Pangali, and Pleheri in the block Daringbadi of the Kandhamal district. The average yield of Niger var. Utkal Niger-150 wasrecorded to be 2.8 to 3.8 q/ha under farmers' practices and 4.8 to 6.2 q/ha under demonstration plots in this study. In comparison to farmers' practices, the demonstration plot's recorded 23 to 28 percentage higher yield. The technological gap was 2.04 q ha^{-1} and extension gap was 0.66 q ha^{-1} under demonstration indicating the need to educate the farmers on technological aspects of niger cultivation and provide technological support to the farmers through various need based extension approaches for the adoption of improved oilseed production technologies to enhance productivity and profitability. The value of technology index was (25.50 per cent) which indicated the feasibility of the demonstrated oil seed technologies for higher productivity.

Keywords: Cluster front line demonstration, yield gap. extension gap, technology index

Introduction

India leads the globe in oilseed production, and the oilseed industry plays a significant role in the national economy of the nation. FAO (2011) states that India accounts for 9%–10% of the world's oilseed area and produces 6–7% of the world's vegetable oils. The scope of expansion of area being meager, productivity growth will have to take the lead in bridging the supply gap. Despite the high energy content of oilseeds, they are usually cultivated in conditions of energy starvation. The spurt in the production in recent years has rendered possible due to improvement in oilseed productivity and strategies adopted by the Technology Mission on Oilseeds.

It is always a matter of concern for the researchers and development administrators to ensure that the real potential of any crop variety should be harvested at the farmers' field. In reality, however, a gap always prevails between what is projected as the potential yield of any variety at research station and what is obtained in farm condition and further what is harvested by the farmers themselves. Technically, this is referred as yield gap of different types and the yield gap is defined as the difference between the maximum-attainable yield and the farm-level yield. Bridging this gap aims to increase oilseeds production, improve the efficiency of land and labour use, and to reduce the production cost and increase food security. The lower oilseed output was discovered to be caused due to marginal areas, unfavorable rain-fed conditions, the use of chemical fertilizers at suboptimal dosages, and the failure to implement plant protection measures. (Jha *et al*., 2011) [5] and Singh *et al.* (2007) [11] described two types of yield gap in terms of technological and extension yield gaps using frontline demonstrations data (FLD) on mustard and observed that there was positive impact of FLD over farmers practices and the farmers were motivated by the new agricultural technologies applied in the demonstration plots, Choudhary *et al*. (2009) [2].

In terms of acreage, output, and exports, India leads the world in Niger. Niger is a minor oilseed crop that is primarily grown in rain-fed conditions. The oil, which is 37–47% of the seed, is pale yellow, nutty and has a pleasant smell. The oil is used in cooking, body anointing, manufacturing paints and soft soaps and for lighting and lubrication.

The primary oilseed crop that the tribal farmers of Kandhamal district grow during the kharif season is niger. Despite being regarded as a minor oilseed crop, Niger is significant due to its 32–40% quality oil content and 18–

24% protein in the seed. Niger oil is used as an illuminant, paint, food, and soap. It can be combined with linseed, sesame, and rapeseed oils and is used as an alternative to olive oil. Niger oil finds applications in paint, food, soap, and illumination. It serves as an alternative to olive oil and can be blended with linseed, sesame, and rapeseed oils. Press cake, which is left over after oil extraction, is also used to make livestock feed. Niger oil has good keeping quality and it has less than 70% unsaturated fatty acids free from toxins.

Even under conditions of poor crop management, low soil fertility, and moisture stress, the crop can produce a higher seed output. Niger has an advantage of yielding oil and has good degree of tolerance to diseases, insect pests and attack of wild animals. Niger has great potential for soil conservation. These attributes favour its cultivation on hilly areas, marginal and sub marginal lands Niger is mainly grown under input-starved conditions on marginal soils in tribal pockets.

This crop is perfect for contingent cropping in rainfed condit ionsdue to its low seed rate, ability to grow on a variety of s oils, and sowing window, which runs from the beginning of the monsoon in June to September or October.

Table 1: Area under Niger crop in Kandhamal district

Year	Area under Niger (ha)
2017-18	7860
2018-19	8870
2019-20	10910
2020-21	11200
2021-22	9800

It is evident from the above table that Niger is a major oilseed crop grown in Kandhamal district and the area under Niger crop has increased in the district except 2021-22 and it may due to abiotic factors like climate change, erratic rainfall and non availability of quality seed.

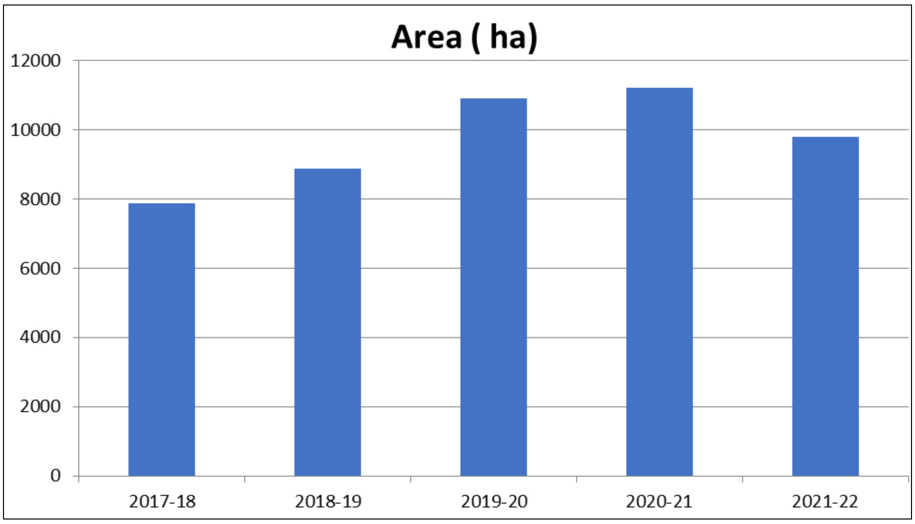

Fig 1: Trend analysis of Niger area in Kandhamal district

Yield Gap in Production

Yield potential (Yp) is defined as the yield of a cultivar when grown in environments to which it is adapted, with nutrients and water non-limiting and with pests, diseases, weeds, lodging, and other stresses effectively controlled. As such, it is distinguished from potential yield, which we characterize here as the maximum yield which could be reached by a crop in given agro climatic conditions. Researchers recognize that there are yield gaps between potential and farm level yields in different ecologies, regions, and nations and yield gaps could be attributed to factors such as biophysical, socio-economic, policy and/or institutional, technology transfer, and linkage to agricultural experts (Evans, 1993) [4].

At the farm level, the most feasible option is to minimize the gap between the potential and actual farm yields and this this gap is not static. Hence, the actual crop yield at the farm level depends on management aspect that is associated with socio-economic in addition to biophysical factors (Bindraban *et al*., 2000) [1]. The yield gap is described as differences between achievable yield and the actual yield under optimal management practices. In the upcoming decades, crop yields will need to rise significantly to meet the world's increasing food demand, which is being driven by population and income growth. The capacity of the world's food production will ultimately be constrained by the availability and suitability of land and water resources for crop production, as well as by biophysical constraints on crop growth.

Front line demonstration is one of the significant tools for transfer of technology. Conducting cluster front line demonstrations on farmer’s field help to identify the constraints and potential of the crop in specific area as well as it helps in improving the economic and social status of the farmers. Font line demonstrations are a concept of field demonstrations evolved by in Indian Council of Agriculture and Research (ICAR) during the inception of Technology Mission on Oilseed crops during mid-eighties. The field demonstrations conducted under close supervision of scientists of the National Agricultural Research System is called front line demonstration because the technologies are demonstrated for the first time by the scientist themselves before being fed into the main extension system of the state department of agriculture (Venkatasubramanian *et al*., 2010) [13].

Front-line demonstrations' most important goal is to showcase recently developed crop production technologies and their management techniques in farmers' fields in diverse micro-farming scenarios across various agro-climatic zones. Through front-line demonstration programs, new and modern technologies with higher production potential under particular cropping systems can be made more widely known to the farmers. The front-line demonstration's goal is to update farmers that they can easily double the crop's current yield by using the recommended package and practices. Keeping the above point in view, the CFLDs on Niger using improved production technologies were conducted with the aim of showing the productive potentials of the integrated production technologies under actual farm situation. The present front line demonstrations were carried out by Krishi Vigyan Kendra, Kandhamal, the critical inputs like seeds of high yielding variety Utkal Niger-150 and other inputs were supplied to the farmers by KVK to find out yield gaps between farmers practices (FP) and Recommended Practices (RP) under Front Line Demonstration programme in three different villages in cluster approach during kharif 2021.

Objective

The current study was under taken to evaluate the performance of HYV, Utkal Niger-150 along with yield attributing parameters and economic of return in Kandhamal district of Odisha in compression with farmers local cultivar. The present study has been undertaken to evaluate the difference between demonstrated technologies and local farmers practices in Niger crop under actual farm situation.

Materials and Methods

The current study was carried out in operational area of Krishi Vigyan Kendra (KVK), Kandhamal, during kharif 2021 and the study was under taken in Daringbadi block of Kandhamal district of Odisha and the block was specifically selected as Niger is the primary oilseed crop grown in this area. The demonstrations were conducted in three different villages ie Greenbadi, Pangali and Pleheri of Daringbadi block, Kandhamal district in cluster approach comprising an area of 10.0 ha. Twenty-five front-line demonstrations conducted in three clusters and each farmer's plot area ranging from 0.2 to 0.4 hectares. All the participating farmers were trained on different aspects of Niger production technologies and recommended agronomic practices and certified seeds of Niger variety Utkal Niger-150 were used for demonstration. The soil of demonstration site was slightly acidic with (pH-5.2 to 5.8) with sandy loam in texture and EC was 0.144 (dS m $^{-1}$). The available nitrogen, phosphorus and potassium was between 216.00, 17.00, 143.00 (Kg ha^{-1}) respectively and available Sulphur was 20 to 32 (kg ha^{-1}) with 0.46 (%) Organic Carbon.

The crop was sown in under rain-fed condition in the 1st week of September with recommended agronomic practices and harvested within 3 rd to 4th week of December and the technologies showcased included, popularization of high yielding Niger variety Utkal Niger-150, Seed treatment with *Vitavax Power* @ 2g kg^{-1} seed, Line sowing with soil test based fertilizer application, pre - emergence application of weedicide Pendimethalene @ 1.0 lit ha^{-1} for management of weed (*Coscuta reflexa*) along with need based plant protection measures for management pod borers. Under this demonstration, HYV Niger var Utkal Niger-150 which was released in year 2007 was used and it has potential yield of 650-700 kg ha^{-1}, 38-40% oil content, duration 105-110 days with black seed, tolerant to Alternaria and Cercospora leaf spot diseases.

The field was ploughed two times and planking was done after each ploughing, Prior to sowing seeds were treated with *Vitavax Power* @ 2g kg^{-1} seed and seed rate was 10 kg ha^{-1}. Need based plant protection measures were taken, along with soil test based fertilizer application (based on the recommended dose of (40:20:20 NPK / kg ha-1) and alternate sprayings of Imidachloprid @ 4ml/10 liter of water and Neem oil @ 5 ml / liter was followed. In case of local checks existing farmer’s variety (Desi Til/ Local Til) being used by farmers. The farmers’ practices were maintained in case of local checks. The field observations were recorded for various parameters from demonstration plot and farmers plot as well. Parameters like seed yield was recorded at maturity stage and the gross returns (Rs ha $^{-1}$) were calculated on the basis of existing market price of the produce. The data were statistically analyzed using statistical techniques, and the extension gap, technology gap, technology index, and B:C ratio were computed. The following formulas have been used to estimate the technology gap, technology index, and extension gap. Plots dedicated to farmer's practices (FP) were preserved as a local control in the comparative analysis. The data obtained from demonstration practices (DP) and famers practices (FP) were analyzed for technological gap, extension gap, technological index and benefit cost ratio study as recommended by Samui *et al*., (2000) as given below.

Technology gap = Pi (Potential yield) - Di (Demonstration yield)

Extension gap = Di (Demonstration Yield) - Fi (Farmers yield)

$$\text{Technology index} = \frac{\text{Technology gap}}{\text{Potential Yield}} \times 100$$

Table 2: Agronomical parameters of Niger observed in demonstration and farmers field

Treatment	Plant height at 90 DAS (cm)	No of branches /plant (No)	No of capitula/plant (No)	1000 seed wt (g)	Seed yield (q ha^{-1})
Farmer’s practice (FP)	65.68	10	18.6	3.31	3.80
Recommended practice (RP)	62.90	12	22.9	3.78	4.46

The data on crop growth parameters as reported in Table- 2 indicated that the number of capitula per plant in case of Utkal Niger -150 was 22.9 as compared to 18.6 in farmer’s practice, which was 21.9% higher. Among the two varieties, Utkal Niger -150 under demonstration plot recorded an average plant height 65.68 cm where as it was 62.9 cm in local variety. The result indicated that average seed yield of Niger in FP practices was 3.80q ha^{-1} and in RP practices it was 4.46 qha^{-1}. By conducting cluster front line demonstration of intervention practices of proven technologies in farmer's field, yield potential of Niger enhanced by (17.36%) which increased in the income level of farmers. The findings were supported by the findings of Jhala *et al*. (2005) [6] and Malve, *et al*. (2020) [8].

Table 3: Demonstration yield over farmer's existing yield

Cluster	Farmer's Yield (q ha^{-1})	Area (ha)	Number of Demonstration	Demonstration Yield (q ha^{-1})	Yield increase (%)	Avg.	
				Max.	Min.		
Cluster I	3.9	4.0	10	6.1	3.8	4.8	23.07
Cluster II	3.7	3.0	8	5.5	3.7	4.1	10.81
Cluster III	3.8	3.0	7	5.8	3.5	4.5	18.42

It was revealed from the table -3 that average seed yield of Utkal Niger -150 under demonstration was recorded with range 4.1 q ha^{-1} to 4.8 q ha^{-1} with range (3.5 to 6.1). It was concluded from the above table that in all the clusters the seed yield of the variety Utkal Niger -150, under recommended package and practices was higher than farmers existing variety. This study indicated that there was a significant yield gap between farmers practice and demonstration practices.

Table 4: Yield Gap Analysis under farmer's practice and demonstration

Treatment	Mean Yield (q ha^{-1})	Standard Deviation	Standard Error of Mean *SEM(±)*	Variance	Yield increase over FP (%)	't' Value	p- value equals
Farmer's practice (FP)	3.80	0.36	0.05	0.07	17.36	31.51*	*(p= 0.000)*
Recommended practice (RP)	4.46	0.25	0.04	0.06			

(The test statistic 't' equals 31.51, Indicates significance value at p=0.05 critical value, t critical 2.06)

The calculated 't' *value* (31.51) was found to be significant, indicating a substantial difference in yield between recommended practice and farmer's practice. It was concluded that yield variation was more in case of farmers practice as compared to recommended practice (RP). The average yield of Niger under Farmers Practice (FP) and Recommended Practice (RP) in this demonstration differed significantly. The results were consistent with the research conducted by *Singh et al.* (2007) [11] and *Katar et al,* (2011) [7].

Table 5: Technology gap, extension gap and technology index of Niger var. Utkal Niger-150

Treatment	Average Yield (q ha^{-1})	Technology gap (q ha^{-1})	Extension Gap (q ha^{-1})	Technology Index (%)
Farmer's practice (FP)	3.80	2.04	0.66	25.50
Recommended practice (RP)	4.46			

It was found from Table 5 that there was a technological gap of 2.04 q ha-1 and an extension gap of 0.66 q ha-1 with technological index 25.50 percent as well. The yield potential of Niger was greatly enhanced, thereby raising the income level of farmers, through the implementation of cluster front line demonstration of intervention practices of proven technologies in farmer's fields. The technology index showed the feasibility of the improved technology at the farmer's field. The lower value of the technology index, the more is the feasibility of the technology. Such fluctuation in technology index during the study period may be attributed to the dissimilarity in soil fertility status, weather condition, non-availability of irrigation water at critical stages and insect-pest attack. These findings were corroborated with the finding of Mokidue *et al.* (2011) [9].

Economic Analysis

The economics and B:C ratio of farmers practice and demonstration practice have been presented in Table 6. Economic analysis was prepared and taking input and output prices of commodities prevailed during the demonstration and cost of cultivation, gross return, net return and benefit cost ratio were calculated. Use of certified seeds for crops, sowing method, seed treatment, recommended dose of fertilizer, proper pest management etc, all of these are the main reasons for high cost of cultivation in demonstration fields than local check. The results on economic analysis of Niger production revealed that the gross expenditure in case of recommended practice (RP) was higher than farmers practice, (FP). Similarly, net return was higher under demonstration and it was due to higher productivity of the demonstrated variety only. By conducting cluster front line demonstration of intervention practices of proven technologies in farmer's field, yield potential of oilseed crop has shown an improvement to a great extent which amplified the income level of farmers. The results were in agreement with the findings of Yogesh *et al.* (2018) [14] and, Singh *et al.* (2007)) [11].

Table 6: Cost of cultivation of Niger Var Utkal Niger under demonstration

Treatment	Gross Cost (Rs ha^{-1})	Gross Return (Rs ha^{-1})	Net Return (Rs ha^{-1})	B: C Ratio
Farmer's practice (FP)	8900	19890	10990	2.23
Recommended practice (RP)	10500	27183	16683	2.58

The HYV variety Utkal Niger-150 recorded higher gross return Rs 27183 per ha, which was (37.2%) higher than farmers practice (Rs 19890 per ha) and it was due to higher productivity of variety Utkal Niger-150 under demonstration. The Benefit Cost ratio was 2.58 under demonstration followed by 2.23 under farmers practice. These results were in agreement with the findings of Katare *et al.* (2011) [7].

Conclusion

An effort to bridge the yield gaps not only increases the oilseed yield and production, but also improves the efficiency of land and labour use, reduces production costs and increases sustainability. Exploitable yield gaps in oilseeds are caused by a number of factors, including institutional, biological, socioeconomic, and physical limitations, which can be successfully addressed with government assistance and participatory research. Intense extension efforts are required in states like Odisha, where there is a greater yield gap in oilseed crops, to increase farmers adoption of crop-specific advanced technologies and popularize high-yielding oilseed crop varieties to close these gaps. Location- and area-specific variety development and adoption should go hand in hand with extension efforts.

Conflict of Interest Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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