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Economic Analysis of the Effect of Nitrogen and Phosphorous Fertilizer Application for Sorghum Production at Alduba, South Omo, South Western Ethiopia

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Abstract: A field experiment was conducted on sandy clay soils of Alduba, South omo, south western Ethiopia for two consecutive years with the aim of determining the optimal fertilizer application rate and the most profitable level for sorghum production. Twenty treatment combinations were made from five levels of nitrogen 0 kg of N ha^{-1}, 23 kg of N ha^{-1}, 46 kg of N ha^{-1}, 69 kg of N ha^{-1} and 92 kg of N ha^{-1} with four level of phosphors 0 P kg of ha^{-1}, 10 kg of P ha^{-1}, 20 kg of P ha^{-1} and 30 kg of Pha^{-1}. The experimental design was a randomized complete block design (RCBD) with three replications. The sorghum improved variety' Teshale' was planted early in Ethiopian 'Meher' season of 2014 and 2015 for two years. Based on the objective function of profit maximization to determine the optimum returns, the highest two years average grain yield (2.689 tones ha^{-1}) was recorded at a fertilizer application rate of 46 kg N ha^{-1} and 30 kg P ha^{-1} with a gross margin of 19703.27 ETB, net returns of 12991.57 ETB and a benefit-cost ratio of 1.4. This shows that farmers in the Alduba of south omo zone stand in a better position to make more profit from sorghum production.

Keywords: Alduba, The Optimal Fertilizer Application Rate, Resource–Poor Farmers, Profit

1. Introduction

Sorghum (Sorghum bicolor L.) belonging to the family poaceae, is an important dual purpose crop. Sorghum [*Sorghum bicolor* (L.) Moench] is the fifth most important cereal crop worldwide and it is the third most important crop in Ethiopia [1].

Sorghum is one of the leading traditional food crops in Ethiopia comprising 15-20% of the total cereal production in the country [2, 3].

It is the fourth most important food crop after maize, wheat and tef and also the most important in the drier parts of the country [1]. It is the fifth most important cereal crop in the world [4, 5].

It is a staple food crop on which the lives of millions of poor Ethiopians depend. It has tremendous uses for the Ethiopian farmer and no part of this plant is ignored [6]. Besides being a major source of staple food for humans, it serves as an important source of feed and fodder for animals. Sorghum exhibits a wide geographic and climatic adaptation. It also requires less water than most cereals; hence it offers great potential for supplementing food and feed resources [7]

Sorghum grows in a wide range of agro ecologies most importantly in the moisture stressed parts where other crops can least survive and food insecurity is rampant [6].

In the year 2005, sorghum was grown worldwide on 43,727,353 ha^{-1} with an output of 58,884,425 metric tons

The productivity of sorghum varies across the different parts of the world. The world average yield being 1314 kg/ha, and yield of developed countries is 3056 kg/ha and that of developing countries is 1127 kg/ha. Despite the low productivity in the developing countries, they accounted 90% of the area and 77% of the total output produced [4].

Ethiopian national average yield amounts to 1302 kg/ha [5]. The low productivity of sorghum in the developing countries can be attributed to biophysical, socio-economic and policy related factors affecting directly and indirectly sorghum production. One reason could be the low level of sorghum research investment in human, financial and material resources development and low input production system.

Nitrogen and phosphorous are the essential elements required for plant growth in relatively large amounts. However, deficiencies of Nitrogen and phosphorous are common. Soil nutrients become depleted due to leaching of nitrogen, fixation of Phosphorous, soil erosion, and removal of crops. [8]

The major challenge before researchers therefore is to evolve ways of increasing the sorghum yield per hectare. This would not only ensure the continuous availability of sorghum for the ever increasing population, it would also improve the income earning capacity of the resource-poor farmers responsible for producing the bulk of the sorghum in Alduba, south omo zone, southwestern Ethiopia.

The sorghum producer is rational in the economic sense, ever seeking ways of maximizing the returns from his lean resources which are not only scarce but have alternative uses. This study was thus designed to determine the application rate among of different rates of Nitrogen and Phosphorous fertilizer for yield and yield components of sorghum.

2. Materials and Methods

2.1. Study Area Description

The study was conducted in 2014 and 2015in Alduba, South Omo Zone. Geographically, this study area lies between 36°.38'-37°.07'E longitude and 5°.01-5°.73N latitude. The particular site, Alduba, is one of sub-center under the Jinka agricultural research center, which has been targeted for crop production, is located about 60 kms South of the Jinka town. Geographically, it is found at E 36° 36' 30.8" Longitude and N 05° 25' 00" latitude and at an altitude of 1343 meters asl. It is characterized by gentle to flat land features. The type of soil is *NITISOLS.* The soil is texturally sandy clay, moderately acidic. The annual average rainfall of the woreda ranges between 601 to 1600 mm. The minimum and maximum annual temperature of 27.5°C and>27.5°C, respectively. Rainfall of the woreda is bimodal, small rains start in February to April interrupted by drought whereas; the second rain starts at July and ends at October with very big variations in distributions and amount. The study area has diversity of climate, soil, and land forms. The topography of the woreda includes mountains, hills, uplands and lowland plains. The woreda generally experiences two cropping seasons namely belg and meher.

2.2. Experiment and Design

The experiment was laid out in a 5 x 4 factorial in a Randomized Complete Block Design. The experimental site was ploughed and harrowed before sowing. The improved sorghum cultivar 'Teshale' [9] was used for the experiment. Plot size was 5x 5 meters. Furrow rows were made manually in spacing of 75 cm apart The sorghum seed was drilled manually and thinned by 20cmspacing between plants. The experiment consisting of twenty treatments having combinations made from five levels of nitrogen 0 kg of N ha^{-1}, 23 kg of N ha^{-1}, 46 kg of N ha^{-1}, 69 kg of N ha^{-1} and 92 kg of N ha^{-1} with four level of phosphors 0 P kg of ha^{-1},10 kg of P ha^{-1}, 20 kg of P ha^{-1} and 30 kg of Pha^{-1}. Sources of Nitrogen was Urea and DAP/TSP for Phosphorous. Full dose of Phosphorous and half dose of Nitrogen were applied at planting and the remaining half dose of Nitrogen were used at knee height (50cm. height). The plots were kept free by hand weeding.

2.3. Data Collection and Soil Sampling

Treatment effects were determined using plant height, 1000-seed weight, above ground biomass, above ground plant height, panicle length and grain yield. Composite soil sample was collected from (20-30 spots) before planting in zigzag movement with the sampling depth of (0-20) cm, Soil sample after harvest were collected from every plot (in 6-8 spots /auger points) and the soil physico-chemical properties.

2.4. Data Analysis

Analysis of variance was performed using the GLM procedure of SAS Statistical Software Version 9.1 [10]. Effects were considered significant in all statistical calculations if the P-values were < 0.05. Means were separated using Fisher's Least Significant Difference (LSD) test.

2.5. Economic Analysis

Grain yield data were economically evaluated using profitability analysis for the feasibility of fertilizer application. In order to determine the profitability of sorghum produced from application of different Nitrogen and Phosphorous fertilizer rate, the following, parameters were estimated:

(i). GM = TR – TVC
Where GM =Gross margin (ETB/ha)
TR =Total revenue (ETB/ha)
TVC =Total variable cost (ETB/ha)
(ii). Return/Birr invested = GM/Total fixed cost
(iii). NR = GM – TFC
Where NR = Net return (ETB/ha)
TFC = Total fixed cost (ETB/ha)
(iv). TCP = TVC + TFC
Where TCP = Total cost of production.
(v). Benefit-cost ratio = NR / TCP

3. Results and Discussion

According to Results in (table 2) Though no significant variations observed for grain yield of sorghum varied with different levels of fertilizer application in both years at (P≤5%) level, the highest yield 2.898 ton /ha in the year 2014 and 2.48 ton/ha in the year 2015 were recorded by treatment plot receiving 46 kg N ha^{-1} and 30 kg P ha^{-1} where as the lowest grain yields 1.2902 ton/ha and 0.966 ton/ha were recorded by control plot without any fertilizer application in two consecutive years.

Table 1. *The grain yield and yield components of sorghum as affected by Nitrogen and phosphorous fertilizer for two years in the target area.*

Year 2014						**Year 2015**					
Trt no.	**Treatment codes**	**Yield ($tonha^{-1}$)**	**Biom ($kgha^{-1}$)**	**Plant height (cm)**	**1000 Seedw.t(g)**	**Trt no.**	**Treatment codes**	**Yield ($tonha^{-1}$)**	**Biom ($kgha^{-1}$)**	**Plant height (cm)**	**1000 Seedw.t(g)**
12	46,30 NP kg/ha	2.8980	8333.3	149	30.84	12	46,30 NP kg/ha	2.48	12820	203.4	22.33
16	69,30 NPkg/ha	2.796	8061.7	146.0	28.7	19	92,20 NP kg/ha	2.34	11573	204.13	22.33
11	46,20 NP kg/ha	2.7340	8205.3	147	21.67	2	0,10 NP kg/ha	2.202	11260	213.33	22.67
15	69,20 NP kg/ha	2.6900	8300.0	129.8	20.55	17	92,0 NP kg/ha	2.072	9093	197.93	21.33
20	92,30 NP kg/ha	2.5340	8133.3	147.3	27.1	15	69,20 NP kg/ha	2.014	1032	193.73	22.33
8	23,30 NP kg/ha	2.4767	7088.0	141.8	27.4	3	0,20 NP kg/ha	2.012	1010	206.53	23.0
7	23,20 NP kg/ha	2.4057	7566.7	140.3	30.3	4	0,30 NP kg/ha	1.982	10040	191.8	20.0
14	69,10 NP kg/ha	2.3570	7236.0	142.9	27.1	16	69,30 Npkg/ha	1.799	12800	212.67	23.33
10	46,10 NP kg/ha	2.1873	7640.0	142.3	30.773	11	46,20 NP kg/ha	1.766	10680	209.0	24.33
6	23,10 NP kg/ha	2.1320	7120.0	142.4	26.3	20	92,30 NP kg/ha	1.736	9667	199.87	22.67
19	92,20 NP kg/ha	2.0587	7586.7	140.2	26.4	7	23,20 NP kg/ha	1.704	9680	204.4	21.67
18	92,10 NP kg/ha	2.0233	6696.0	136.2	24.0	6	23,10 NP kg/ha	1.672	9647	192.33	21.667
5	23,0 NP kg/ha	1.8721	5910.0	133.3	24.9	5	23,0 NP kg/ha	1.588	7780	193.4	21.0
2	0,10 NP kg/ha	1.8593	6320.0	139.5	23.1	9	46,0 NP kg/ha	1.526	9580	203.8	19.667
13	69,0 NP kg/ha	1.7747	7533.3	131.0	25.5	8	23,30 NP kg/ha	1.456	8910	194.5	23.0
9	46,0 NP kg/ha	1.7700	7896.0	148.0	27.1	10	46,10 NP kg/ha	1.354	7887	212.6	26.667
4	0,30 NP kg/ha	1.7503	7433.3	139.5	27.6	18	92,10 NP kg/ha	1.349	11040	192.55	22.00
3	0,20 NP kg/ha	1.7240	6706.7	141.8	22.7	14	69,10 NP kg/ha	1.118	10727	211.2	22.33
17	92,0 NP kg/ha	1.6487	6469.3	143.5	25.0	13	69,0 NP kg/ha	1.104	8473	196.33	19.33
1	0.0 NP kg/ha	1.2902	4134.7	137.4	27.37	1	0.0 NP kg/ha	0.966	5256	177.4	19.667
	Means	2.149	7178.687	141.01	26.32		Means	1.721	9902.3	200.513	22.06

This result is not similar with the findings of previous work in Kenya where the interaction of 40 $kgha^{-1}$ of N and 20 $kgha^{-1}$ of P significantly highest grain yield over all fertilizer levels [11].

The maximum biomass (8333.3 $kgha^{-1}$) and (12820 $kgha^{-1}$) in years 2014 and 2015 respectively were gained by treatment receiving 46,30 NP $kgha^{-1}$ where as the minimum above ground biomass (4134 $kgha^{-1}$) and (5256 $kgha^{-1}$) in years 2014 and 2015. respectively were recorded by control plot without any application of fertilizer even though the results were statistically not significant at ($P \leq 5\%$) level. Similarly, Plant heights of sorghum was statistically not significant ($P \leq 5\%$) highest (149cm) and (212.67cm) in two consecutive years were recorded by treatments receiving (46,30NP kg/ha) and 69,30NP kg/ha respectively. The shortest of all plant heights 131cm and 177cm in two consecutive years were recorded by fertilizer levels 69,0 NP $kgha^{-1}$ and control plots respectively. The highest 1000 seed weights (30.84gram) in year 2014 and (26.667 gram) in year 2015 were gained by application of 46,30NP kg/ha) and 46,10 NP kg/ha respectively.

Table 2. *Sorghum grain yield (ton/ha) by Nitrogen – phosphorous fertilizer interaction in year 2014.*

Nitrogen fertilizer N ($Kgha^{-1}$)	**Phosphorous fertilizer P ($kgha^{-1}$)**				**Mean**
	0	**10**	**20**	**30**	
0	1.2902	1.8593	1.724	1.753	1.656625
23	1.872	2.132	2.4054	2.4767	2.221525
46	1.77	2.1873	2.734	2.898	2.397325
69	1.774	2.357	2.69	2.796	2.40425
92	1.6487	2.0233	2.0587	2.534	2.066175
Mean	1.67098	2.11178	2.32242	2.49154	

Table 3. *Sorghum grain yield by Nitrogen – phosphorous fertilizer interaction in year 2015.*

Nitrogen fertilizer N (Kgha^{-1})	Phosphorous fertilizer P (kgha^{-1})				Mean
	0	10	20	30	
0	9.66	2.202	2.012	1.982	1.798
23	1.588	1.672	1.704	1.456	1.605
46	1.526	1.354	1.766	2.48	1.7815
69	1.104	1.118	2.014	1.799	1.50875
92	2.072	1.3495	2.34	1.736	1.874375
Mean	1.4572	1.5391	1.9672	1.8906	

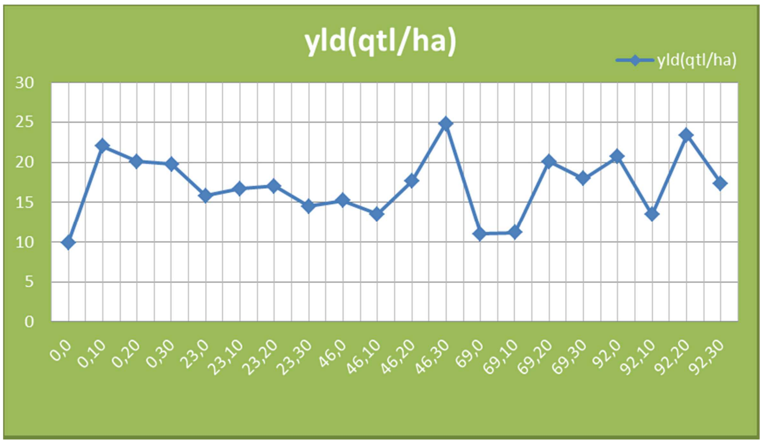

Figure 1. *Grain yield of sorghum in Nitrogen-Phosphorous interaction in year 2014/15.*

As it was indicated in the (Figure 1) nitrogen complementarily played role in uptake of phosphorous. Phosphorous and nitrogen acting independently did not increase grain yield. This is in agreement with the previous research report [12]. 46 kgNha^{-1} and 30 kgPha^{-1} with interaction brought higher yield, but solely could not.

Table 4. *Profitability Analysis of two years of average grain yield from the effect of the applied different rate of NP fertilizer on sorghum production of 2014 and 2015.*

Treatment codes	NP level kg/ha	Two years Average Grain yield (ton ha^{-1})	Revenue in Average of two years (8750ETB/ton)	Total variable cost (TVC) in ETB (average)	Average Total fixed cost (ETB)	Total cost of production (ETB)	Gross margin (ETB)	Return/ETB invested	Net return (ETB)	Benefit-cost ratio
12	46,30 NPkg/ha	2.689	22132	2428.73	6711.7	9140.43	19703.27	2.9	12991.57	1.4
16	69,30 NPkg/ha	2.568	21129	3008.59	6711.7	9720.29	18120.41	2.7	11408.71	1.2
11	46,20 NPkg/ha	2.468	20294.5	2005.73	6711.7	8717.43	18288.77	2.7	11577.07	1.3
15	69,20 NPkg/ha	2.381	19566	2585.59	6711.7	9297.29	16980.41	2.5	10268.71	1.1
20	92,30 NPkg/ha	2.274	18695.5	4059.05	6711.7	10770.75	14636.45	2.2	7924.75	0.7
8	23,30 NPkg/ha	2.244	18455	1848.86	6711.7	8560.56	16606.14	2.5	9894.44	1.2
7	23,20 NPkg/ha	2.1938	18046.3	1425.86	6711.7	8137.56	16620.44	2.5	9908.74	1.2
14	69,10 NPkg/ha	2.078	17073.75	2162.59	6711.7	8874.29	14911.16	2.2	8199.46	0.9
10	46,10 NPkg/ha	1.97665	16254.7	1582.73	6711.7	8294.43	14671.97	2.2	7960.27	1
6	23,10 NPkg/ha	1.934	15906	1002.86	6711.7	7714.56	14903.14	2.2	8191.44	1.1
19	92,20 NPkg/ha	1.88135	15476.	3165.46	6711.7	9877.16	12310.54	1.8	5598.84	0.6
18	92,10 NPkg/ha	1.84765	15199.	2742.46	6711.7	9454.16	12456.54	1.9	5744.84	0.6
5	23,0 NP kg/ha	1.73	14237	579.865	6711.7	7291.565	13657.14	2	6945.44	1
2	010 NP kg/ha	1.69265	13922.7	423.80	6711.7	7135.5	13498.9	2	6787.2	1
13	69,0 NP kg/ha	1.61535	13286.8	1739.59	6711.7	8451.29	11547.21	1.7	4835.51	0.6
9	46,0 NP kg/ha	1.562	12834.5	1159.73	6711.7	7871.43	11674.77	1.7	4963.07	0.6
4	0,30 NP kg/ha	1.54965	12734.4	1269	6711.7	7980.7	11465.4	1.7	4753.7	0.6
3	020 NP kg/ha	1.421	11647.	846	6711.7	7557.7	10801	1.6	4089.3	0.5
17	92,0 NP kg/ha	1.37635	11286.	2319.46	6711.7	9031.16	8966.54	1.3	2254.84	0.2
1	0.0 NP kg/ha	11.401	9368.3	0	6711.7	6711.7	9368.3	1.4	2656.6	0.4

Note: ETB stands for (Ethiopian birr)

The highest two years average grain yield 2.689 tones/ha [Table 3] was recorded in the treatment with application of 46,30kg N P ha^{-1} in years 2014 and 2015 where as he lowest of all average grain yield was gained by control plot, without any application of fertilizer. In terms of cost, the highest total variable cost of 4,059.05ETB which is the cost DAP and urea fertilizer which varies from year to year and area to area related to transportation cost, and the highest total cost of production (10770.75 ETB) was incurred under the fertilizer application of 92, 30 NP kg ha^{-1} in the target area.

The total fixed cost 6,711.7ETB did not vary among different levels of nitrogen and phosphorous fertilizer rates from the lowest unfertilized control to highest 92,30 NPkgha^{-1}. These costs are costs of land, labor and seed were constant for all treatment plots as well as for two years particularly to experimental environment.

The highest gross margin 19,703.27 ETB, net return 12,991.57 ETB, and benefit cost ratio of 1.4 (table 3) respectively were coming from the fertilizer level 46,30 kg ha^{-1} followed by 46,20 kg ha^{-1} having gross margin of 18,288.77 ETB, net return 11,577.07 ETB and benefit - cost ratio of 1.3 (Table 3).

Though the benefit -cost ratio is positive for all levels of fertilizer application besides greater than or equal to 1 for 46,30 NP kg/ha^{-1}, 69,30NPkgha^{-1}, 46,20 NP kgha^{-1}, 69,20 NP kgha^{-1}, 23,30 NP kg/ha^{-1}, 23,20 NP kgha^{-1}, 46,10 NP kgha^{-1}, 23,10 NP kgha^{-1}, 23,0 NP kgha^{-1} and 0,10 NP kgha^{-1}, the highest of all 1.4 is gained by fertilizer application level of 46,30 NP kg/ha^{-1}. The benefit -cost ratio below 1 or (<100%) are unacceptable [13].

4. Conclusion and Recommendation

It has been shown in this study that Nitrogen and phosphorous fertilizer for sorghum production could make an important contribution to optimize profit through increasing production and productivity of sorghum in areas like Alduba, South omo where there is low practice of using improved technologies such as optimum level of fertilizer. To this end, use of improved sorghum technologies such as optimum level of fertilizer could be one of the alternatives to improve productivity by small farmers. However, the use of optimum level of fertilizer to maximize profit is not yet studied in the area. Thus, this research work was initiated with the objective to investigate the impact of including optimum Nitrogen and Phosphorous fertilizer and most profitable fertilizer application rate for for improved sorghum variety on the existing production system in target area, which is of paramount important. Study on economic analysis of nitrogen and phosphorous fertilizer for sorghum production was conducted under rain fed conditions in 2014 and 2015. The experiment was carried out using the randomized complete block design (RCBD) with three replications at Alduba in 2014/15. During the field implementation, improved 'Teshale' sorghum variety was used. According to the results of analysis of variance, the highest grain yields (2.898 tones ha^{-1} in the year 2014 and 2.48 tones ha^{-1} in the year 2015 respectively were recorded from plot receiving the fertilizer rate 46 kg N ha^{-1} and 30 kg P ha^{-1}. According to economic analysis result, this level of nitrogen and phosphorous fertilizer application is the level at which the highest gross margin, net return and benefit- cost ratio achieved. So, which is economically optimum and profitable. Therefore, it can be concluded that application of 46,30NP kg/ha fertilizer in the target area is preferable to maximize profit that can be gained from sorghum production.

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