Improving Sorghum Productivity in Waterlogged Vertisols in North Gondar, Ethiopia

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Sorghum is a major crop in Vertisols of the North Gondar zone in Ethiopia. Due to waterlogging on these Vertisols, the crop may stay in the field for more than seven months and productivity is extremely low. Sorghum production here is facing a multitude of challenges including waterlogging, late season moisture shortages, and pest bird losses. The crop remains in the field alone after all other crops are harvested, exposing it to huge bird damages.

An experiment was conducted in the Gumara-Maksegnit watershed, Lake Tana basin of Ethiopia during the 2013 and 2014 cropping seasons. The objective of this study was to reduce the maturity period and to improve the yield of sorghum through fertilizer application and other management practices. The experiment was laid out in a Randomized Complete Block Design with three replications. Treatments were control (0 kg N ha^{-1}), 23 kg N ha^{-1} applied all at planting ($23N_{1+0}$), 41 kg N ha^{-1} applied all at planting ($41N_{1+0}$), 41 kg N ha^{-1} applied all at knee height ($41N_{0+1}$), 41 kg N ha^{-1} applied half at planting and the remaining half at knee height stage ($41N_{1/2+1/2}$), 64 kg N ha^{-1} applied all at planting ($64 N_{1+0}$), 64 kg N ha^{-1} applied all at knee height ($64N_{0+1}$), 64 kg N ha^{-1} applied half at planting and the remaining half at knee height stage ($64N_{1/2+1/2}$), 87 kg N ha^{-1} applied all at planting ($87N_{1+0}$), 87 kg N ha^{-1} applied all at knee height ($87N_{0+1}$), and 87 kg N ha^{-1} applied half at planting and the remaining half at knee height stage ($87N_{1/2+1/2}$). Sorghum seeds were initially sown on flat soil beds, and later drainage ridges between the sorghum rows were constructed three weeks after sowing to facilitate drainage of the excess water. Figure 1 shows typical differences between unfertilized (left) and fertilized crops (right).

Figure 1. Farmer's managed (a'), and researcher's managed (b') sorghum fields at flowering.

Results showed that fertilizers applied at different stages significantly affected grain yield and yield parameters of sorghum. Maximum grain yield (4046 kg ha^{-1}) was obtained

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at 87 kg N ha^{-1} with a split application of half at planting and half at knee height of the crop (Table 1). The economic analysis showed that the application of 87 kg N ha^{-1} with the split application was economically profitable for sorghum production in the Gumara-Maksegnit watershed with a marginal rate of return (MRR) of 1207 percent. This result indicated that for each 1.0 $US additional investment on fertilizer, farmers here can earn a return of 12.07 $US (Table 2). The mean length of the growing period of sorghum with traditional farmers' practice in the watershed was 209 days. However, by applying recommended fertilizers and ridge management, the growing period of sorghum from planting to maturity was 169-172 days. The growing period was thus reduced by 37-40 days, which helped the crop avoid the water shortage period during the growing season. Reduction in the maturity period also reduces potential yield loss due to bird damage. Previous research results have also shown that waterlogging can cause a significant delay in heading days (Amri et al., 2014).

Table 1. Effect of fertilizer applications on sorghum yields.

Nitrogen fertilizer	P fertilizer	Days to maturity	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})
0	0	209 a*	1189 f	3692 f
$23N_{1+0}$	10	172 b	1956 e	4915 f
$41N_{1+0}$	10	171 bc	2476 d	6716 e
$41N_{1/2+1/2}$	10	168 d	2593 d	7697 de
$41N_{0+1}$	10	168 d	2469 d	8136 cde
$64N_{1+0}$	10	170 bcd	2659 d	8958 cd
$64N_{1/2+1/2}$	10	169 cd	3416 bc	9149 cd
$64N_{0+1}$	10	170 bcd	3105 c	9477 bc
$87N_{1+0}$	10	169 cd	3541 b	10729 ab
$87N_{1/2+1/2}$	10	169 cd	4046 a	11220 a
$87N_{0+1}$	10	172 b	3677 ab	10897 ab
CV (%)		1.14	10.7	16.3

*Means in same column followed by same lower case letter are not significantly differently at α=0.05 using Fisher's Least Significant Difference (LSD) means comparison test.

Table 2. Economic analysis for the effect of split application of nitrogen fertilizer on sorghum.

Nitrogen fertilizer (kg ha^{-1})	P Fertilizer (kg ha^{-1})	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Gross field benefit ($ ha^{-1})	Total costs that vary ($ ha^{-1})	Net benefit ($ ha^{-1})	MRR* (%)
0	0	1189	3692	434.5	5.6	428.9	
$23N_{1+0}$	10	1956	4915	704.4	133.1	571.3	111
$41N_{0+1}$	10	2469	8136	906.5	172.4	734.1	415
$41N_{1+0}$	10	2476	6716	896.1	172.4	723.7	
$41N_{1/2+1/2}$	10	2593	7697	944.4	178.1	766.3	740
$64N_{1+0}$	10	2659	8958	978.0	204.9	773.2	
$64N_{0+1}$	10	3105	9477	1133.2	204.9	928.4	
$64N_{1/2+1/2}$	10	3416	9149	1235.2	221.6	1013.6	509
$87N_{1+0}$	10	3541	10729	1291.6	242.4	1049.3	172
$87N_{0+1}$	10	3677	10897	1339.1	242.4	1096.7	
$87N_{1/2+1/2}$	10	4046	11220	1466.5	252.1	1214.4	1207

*MRR – Marginal Rate of Return

References

Amri, M., M.H. El Ouni, and M.B. Salem. 2014. Waterlogging affect the development, yield and components, chlorophyll content and chlorophyll fluorescence of six bread wheat genotypes (*Triticum aestivum* l.). Bulg. J. Agric. Sci. 20(3): 647-657.