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The Effect of Application of Different Rate of N-P Fertilizers Rate on Yield and Yield Components of Sorghum (Sorghum bicolor): Case of Derashe Woreda, SNNPR, Ethiopia

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Abstract
A field experiment was conducted at Derashe woreda, Sagan Peoples zone, SNNPRs, Ethiopia to evaluate the effects of application of different rates of N-P fertilizers on yield and yield components of Sorghum (Sorghum bicolor) this is owing to the rate of N-P fertilizer application varies from site to site due to several factors like soil nutrient status and so on. The aims of this research is to determine the effects of different rates of fertilizer of N-P for sorghum at Derashe woreda, and to determine the yield and yield components of sorghum by application of different rate of N-P inorganic fertilizers. Hence, there is a necessity to determine the definite nitrogen and phosphorus fertilizer requirement of grain sorghum variety to obtain maximum yields and yield components, the experiment contained factorial combination of five levels of N/P (0/0, 23/10, 46/20, 69/30 kg,92/30 ha^{-1}) and was laid out in randomized complete block design with three replications. The results from this study indicated that the inorganic nitrogen and phosphorus fertilizer showed not statistically significant different effect on plant height and sorghum heads but revealed continues increment of height, and heads respectively were significantly increased by application of nitrogen and phosphorus. However, the effects of nitrogen and phosphorus were significantly different at ($P \leq 0.05$) and ($P \leq 0.01$) on plant height, plant lodging, grain yield and total biomass. In general, grain yield, biomass, plant height and sorghum with heads were tended to be recorded highest under NP 92/30 kg ha^{-1} treatment whereas on the contrast of this, the lowest grain yield, biomass weight, plant height, and sorghum with heads were obtained from control (0/0) NP treatment. Hence, the forthcoming investigations ought to focus on the way to the investigations encompassing, different agro-ecology and additional rates of nitrogen and phosphorus applications, under different management practices such as research and farmer's field's normal conditions, which perhaps enable pave the way for fertilizer recommendations for this specific sorghum crop for Derashe woreda.
Keywords: Nitrogen and phosphorus fertilizer, Sorghum, yield and yield components.

INTRODUCTION

Agriculture is the mainstay of the economy of Ethiopia. Currently, the governmental and non-governmental organizations have given special attention to the sector to play a leading role in the economic development of the country. Sustainable agricultural development involves the management and conservation of the natural resource base and the orientation of technological and institutional changes as to ensure the attainment and continued satisfaction of human needs of the present and future generations (FAO, 1995). Thus, sustainable agricultural development is environmentally non-degrading, technically appropriate, economically viable and socially acceptable in the medium term as it conserves (increases) the productivity of land, increases the availability of water and conserves biodiversity. The concept of integrated soil nutrient management which involves the combined use of organic materials and chemical fertilizers have been developed to increase the efficiency of the latter as well as to solve the problem of disposal of organic wastes (Taye, 1996). Moreover, repeated application of chemical fertilizers carrying certain nutrients could reduce soil productivity by adversely affecting physical properties such as soil structure and could result in mining of other macro- and/or micronutrients of the soils to amounts below the critical levels (Prasad and Singh, 1980).

Sorghum (*Sorghum bicolor L. Moench*) is the fifth most important world cereal, following wheat, maize, rice, and barley. It is a staple food in the drier parts of tropical Africa, India, and China. Sorghum, because of its drought resistance, is the crop of choice for dry regions and areas with unreliable rainfall. Sorghum is adapted to wide range of ecological conditions and can be grown under conditions, which are unfavorable for most of the cereals (Onyango *et al*., 1998). Although sorghum is a crop of the plains, it is grown even up to an elevation of 2,400 masl. Most East African sorghum is grown between the altitude of 900 and 1,500 m. The optimum temperature during the growing season ranges from 27 – 32 0C, and the minimum and maximum temperatures for growth are 15 0C and 40 0C, respectively. Extremely high temperatures during the grain formation period reduce the seed yield. It is well adapted and widely grown where the annual rainfall varies from 400 to 700 mm. Its cultivation is limited to tracts with a rainfall of about 1,000 mm as maximum. Similarly, cereals are the most extensively grown crops in Ethiopia contributing about 80% of the total cultivated area and 77% of the total crop production (CSA, 2000). Among the cereals, teff, maize, sorghum, wheat and barley are the main food crops in the country covering about 23, 17, 14, 13 and 10% of the crop lands, respectively (CSA, 2000). Sorghum *(Sorghum bicolor),* with a recorded average yield of about 1.4 t ha -1, is the third principal crop in area coverage (14%) surpassed by teff and maize in the country. Since it is drought resistant, it regularly out-yields maize in many of the drier parts of East Africa (Martin and Leonard, 1987). Sorghum is grown successfully in a wide range of climates, on nearly all soil types and can tolerate considerable soil salinity, as it is adapted to a wide range of environment it is largely produced in the high, medium and low land regions. It is widely produced more than any other crops, in areas where there is moisture stress. Currently sorghum is produced on about 1.3 million hectares of land from which 17.2 million quintals of grains are harvested (MoARD, 1998). The prevailing drought and the importance of the crop for food and feed as well as the use of the stalks for mulch and nursery shade-mat material in coffee growing areas in particular make sorghum a crop of equivalent importance to many other cereal crops in the country as well as the specific study area and its leaf and stalks are used for animal feed and the stalks are also used for construction of house and fence and as fuel wood.

Despite its importance and high genetic diversity, scientific information about the nutrient requirement of sorghum is not yet exhaustively investigated. This coupled with the low and decreasing levels of soil fertility particularly soil N and P levels, for sustainable crop production and soil fertility maintenance. Therefore, this study focuses on evaluating the rate of nitrogen and phosphorus inorganic fertilizers for improved sorghum crop production and soil fertility. The specific objectives of this study were to:

- To determine the optimum rate of fertilizer of N-P for Arguba, Derashe woreda, SNNPR, Ethiopia.
- To determine the yield and yield components of sorghum by application of different rate of N-P inorganic fertilizers for Arguba, Derashe woreda, SNNPR, Ethiopia.

Materials and methods

Description of the Experimental Site

The experiment was conducted on farmers' fields during the main rainy season (June-November) of 2014 in Derashe woreda of South Nation Nationalist Peoples Regional State (SNNP). Derashe is one of the woredas in the SNNPRS. It is endowed with natural forests, rivers, tourist attraction sites, minerals, crops, strong working culture, wildlife, and others. . The total land area of the woreda is 1532.40 Sq. Km. Topographically; the woreda lies between 501-2500 meters above sea level. The total population of the woreda is about 133,543 (2007). The mean annual temperature of the woreda ranges between 15.1 27.50 centigrade. Moreover, the mean annual rainfall ranges between 601- 1600mm. Derashe woreda has wide variety of potential resources for development and investment activities. The population characteristics, the land, cultural setup of the community and other features are vital for development interventions. Agriculture is the major source of income and livelihood for the community; however, due to traditional farming practice, erratic rainfall, low agricultural input utilization and low skilled manpower seem to have hampered the development of the agricultural sector and the phyisco chemical characteristic of the soil was determined and shown in the table below.

Experimental Treatments, Design and Procedures

Experimental Treatments and Design

The treatments considered in the study were a factorial combination of five levels of N (0, 10, 23, 46, 69,92kg ha^{-1}) and four levels of P (0, 10, 20, 30kg ha^{-1}) fertilizers were arranged factor ally. The treatment combinations constituting a total of 20 treatments including the control treatment were randomly allocated to the experimental units within a block in accordance with the requirements of the design. Seedbed preparation was carried out in accordance with the practices followed by the farmers in the area for sorghum crop production. Accordingly, the sorghum seeds were sown on May 31, 2007 by drilling in each planting row based on the seed rate recommended for the variety. Which is 20kg/ha. Finally the space between the plants was adjusted by 20 cm by thinning, and the two outer most rows (40 cm) from both sides of a plot and 0.5 m row length at both ends of each row of plot were left .Hence, 9.6 m^2 (3.2 m x 3 m) of net plot size was used for the collection of data.

Laboratory Analyses

The soil samples were air-dried and ground to pass a 2-mm sieve and 0.5 mm sieve (for total N) before analysis. Soil texture was determined by Bouyoucos hydrometer method. The pH and electrical conductivity of the soils were measured in water (1: 2.5 soils: water ratio). Organic carbon content of the soil was determined following the wet combustion method of Walkley and Black while Total nitrogen by (wet digestion) procedure of Kjeldahl method. The available phosphorus content of the soil was determined by Bray II method.

Result and Discussion

Soil analysis before sowing showed that soil pH, available P, EC, OC and Total N found based on Herrera (2005) classification, nonetheless a result of certain soil chemical and physical properties of the experimental site were showed that medium. The soil analysis result indicated that texture of the soil was clay loam and pH of the soil was 7.2 slightly alkaline according to rating of takalegn (1991), this range is suitable for different crops have different requirements but the optimum pH range for barley is 6.0 - 7.0. Therefore, the pH of soil is suitable for sorghum production (CLDB, 2001). Other soil chemical properties were total Nitrogen (TN) of the experimental site was with percent 0.37. According to Havlin et al. (1999) rating scale the total nitrogen content is low (> 0.15). There for treating or the application of nitrogen source is important for the growth of better crops. The total phosphorus content of the soil was 4 mg Kg^{-1}). According to Olsen *et al*. (1954) rating, (4 to 7). Then available P at the site was low range because of these the application of P source is important for improving the fertility of the soil.

Table 2: Interaction effect of N and P rates on plant height, number of lodged plant, amount of plant with heading, amount of grain yield and amount of biomass weight of sorghum crop: case of Derashe woreda, SNNPR, Ethiopia

Treatment (N,P)	Plant height (cm)	Lodged plant	Plant with heading	Grain yield (kg/ha)	Biomass weight (kg/ha)
0,0	140.067[a]	24.667[a]	58[d]	812.5[f]	10.800[c]
0,10	141.267[a]	9.667[b]	76[cd]	1375[ef]	11.300[bc]
0,20	141.600[a]	8[b]	82[bcd]	1541.7[cdef]	14.600[abc]
0,30	141.533[a]	9[b]	93.33[abc]	1520.8[edf]	14.767[abc]
23, 0	141.667[a]	7.667[b]	96[abc]	1937.5[bcdef]	14.933[abc]
23,10	142.267[a]	6.333[b]	96.67[abc]	1958.3[bcdef]	15.167[abc]
23,20	142.800[a]	5.667[b]	103.33[abc]	2104.2[bcdef]	15.767[abc]
23,30	143.086[a]	5.667[b]	102.67[abc]	2187.5[bcdef]	15.733[abc]
46,0	143.200[a]	5.667[b]	106. 00[abc]	2312.5[bcdef]	15.833[abc]
46,10	143.600[a]	5.667[b]	107[abc]	2500[abcde]	15.967[ab]
46,20	143.867[a]	5.667[b]	107.33[abc]	2562.5[abcde]	16.100[ab]
46,30	143.867[a]	5[b]	108[abc]	2625[abcde]	16.200[ab]
69,0	144.467[a]	4.667[b]	109.67[abc]	2854.2[abcde]	16.400[a]
69,10	145.133[a]	4.667[b]	109.67[abc]	2875[abcde]	16.433[a]
69,20	146.133[a]	4.5[b]	110.67[ab]	2979.2[abcd]	16.733[a]
69,30	146.200[a]	4[b]	113.67[ab]	2979.2[abcd]	17.067[a]
92,0	146.400[a]	4[b]	116.33[a]	3000[abcd]	17.533[a]
92,10	148.267[a]	3.333[b]	116.67[a]	3083.3[abc]	17.700[a]
92,20	148.400[a]	3[b]	117[a]	3458.3[ab]	17.800[a]
92,30	149.733[a]	2.667[b]	121.67[a]	3895.8[a]	18.167[a]
CV (%)	4.288	74.897	19.881	38.782	19.383
LSD(0.05)	10.222	3.223	33.711	1556.5	5.046

- Means with the same letter are not significantly different!

Table 3: Analysis of variance /ANOVA for determination of interaction effect of N and P rates on plant height, plant lodging, plant with heading, grain yield and biomass weight of sorghum crop: case of Derashe woreda, SNNPR, Ethiopia

Sources of variation		Parameters Plant height (cm)	Lodged plant	Plant with heading	Grain yield (kg/ha)	Biomass weight (kg)
Treatment	Degree of freedom	19	19	19	19	19
	Sum of squares	415.309^{ns}	1248.168**	13840.583^{ns}	32964778.650*	205.790*
	Mean square	21.858^{ns}	65.693**	728.452^{ns}	1734988.350*	10.831*
	F value	0.57	2.75	1.75	1.960	1.160
	Pr>F	0.904	0.005	0.069	0.039	0.337
Replication	Degree of freedom	2	2	2	2	2
	Sum of squares	229.476^{ns}	287.799**	2113.633^{ns}	6798437.500*	60.151*
	Mean square	114.738^{ns}	143.899**	1056.817^{ns}	3399218.750*	30.076*
	F value	3.00	6.02	2.54	3.830	3.230
	Pr>F	0.0617	0.006	0.092	0.030	0.051
Error	Degree of freedom	38	38	38	38	38
	Sum of squares	1453.271	836.244	15806.367	33696354.170	354.149
	Mean square	38.244	23.893	415.957	886746.160	9.319
	F value					
	Pr>F					

** = Significant at 1% level (highly significant) * = significant at 5% level (significant)

Plant height

The average height (cm) measured from the ground level to the tip of the panicle of five randomly selected plantsfrom the net harvested rows of each experimental unit was reported as average plant height of the respective plot (Tables 1). Application of N/P fertilizers (Table 1and Table 2) affected the mean sorghum plant height not significantly different at ($P \leq 0.05$) as well as ($P \leq 0.01$).

The mean plant height due to applications of N/P fertilizers (Table) table of ANOVA (table 3) did not affect plant height significantly ($P \leq 0.05$); taking the average across all levels of applied N + P fertilizers, the mean height of sorghum plant ranged from 140.067 cm (height recorded at control treatment) to 149.733cm. Although the differences were not statistically significant, all these mean plant height values were significantly taller than the control treatment (140.067cm) as indicated in table1.This result was in agreement with Yousif (1993) finding who reported that the application of optimum fertilizer nutrients like N and P gave the highest plant height, similarly Mohamed (1990) stated that nitrogen and phosphorus significantly increased plant height and Elasha (2007) also indicated that applying no nitrogen and phosphorus resulted in a significantly shorter plants compared to fertilized, generally, the increased rates of N, and P increased the plant growth and biomass and the increased amounts of N-P increases the production of sorghum crop like height of the sorghum plant (Bayu et al.,2006, Robinson et al., 1977, Oplinger, 1973 and. Oelke, 1971).

Grain yield

The data on sorghum grain yield as affected by the application rates of inorganic N-P fertilizer application rates are presented in table 1(table of effect of interaction) and table 2 (table of ANOVA), As indicated in Table 1 and 2, grain yield was significantly affected by the application rates of the inorganic N-P fertilizers at ($P \leq 0.05$).

The grain yield of sorghum as influenced by the different application rates of inorganic N-P fertilizers. Increasing the rates of N/P fertilizers from 0/0 to 92/30 kg ha -1 increased the yield of the crop from 812.5 to3895.8 kg ha -1. Thus, compared to the control treatment, the highest rate of N/P (92/30 kg ha -1) increased sorghum grain yield by 379.5%. Accordingly, the yield obtained from the control treatment was significantly lower ($P \leq 0.05$) than the yields obtained due to the application of all of the different rates of NP fertilizers (Table 2). This implies that the grain yield was low without application of either of the soil fertility amendments mechanisms.

In this aspect, the result of this work is in lined with the work of Duraisami*et al.,* (2001) who reported that inorganic N showed higher N uptake and yield of sorghum over mineral N application alone and this might be due to the improved physical environment with better N availability for the plant sorghum. Similarly, the works of Kanchikerimath and Singh (2001) also support the results of this study. Based on the findings of their studies, they stated that soil organic matter content and soil microbial activities are vital for the nutrient turn over and long-term productivity of the soil that nutrient availability is enhanced by balanced application of nutrients and manure. The works of Omiti and Freeman (1998) also declared another supportive result from Kenya who suggested the other likely way forward to improve soil fertility management is to encourage the use of small quantities of inorganic fertilizer in combination with traditional practices such as agro-forestry practices. Similarly, Snapp et al. (1998) stated that, intensification of combined use of small amount of inorganic fertilizer (especially P), animal manure and legumes which provide some grain yield with high quality residues (organic sources) offer enhanced nutrient efficiency with improved food security in Malawi and Zimbabwe. They in addition, commented on the attitudes in which soil fertility technologies have been viewed as substitutive alternatives rather than investigating additive approaches. Similarly, Shrotriya (1998) reported that balanced application of N-P caused up to 122% increase in sorghum yield in India and Bumb and Bannante (1996) also confirmed that increased plant growth with optimal N, and P application provides good vegetative cover which resulted in high grain yield of sorghum plant, and the research findings of Regessa Kumssa (2005) is also agreed with this research report as well and the findings of Mesfin Kassa and Zemach Sorsa (2015) is also in lined with this findings. .

Biomass weight

The total biomass yields of sorghum were affected significantly different at ($P \leq 0.05$) by the main effect of applied rates of inorganic N-P fertilizers (Table 1 and ANOVA table 2). Biomass increased consistently with increasing rates of application of inorganic N-P fertilizers from 10.800 in the control (0/0 N/P) treatment to 18.167. Moreover, the use of mineral fertilizer of N and P nutrients had improved the biomass yield of the crop. The treatment combination of 92 N +30 kg P ha $^{-1}$ where the highest biomass yield was registered as compared the control treatment (0/0 N/P) which was lower than 7.37 kg/ha.

The lower biomass yields recorded on the control (0/0 N/P) revealed that neither sole application nor a lower rates are sufficient to improve crop production significantly and to maintain soil fertility status at a high level. Thus, the results of the present study substantiate the fact that earlier researchers stressed that lack of adequate nutrient supply and poor soil structure are the principal constraints to crop production under low input agriculture systems (Ouedraogo*et al.,* 2001). This research findings is also in lined with report of (Regessa Kumssa. 2005, Azrag, and Dagash, 2015) who ascertained that the increasing application of fertilizer nutrients such as N and P increases the grain yield and biomass weight of sorghum significantly and similarly, Yousif (1993) confirmed that fertilizer nitrogen and phosphorus has contributed more than any other fertilizer towards increasing yield of grain crops and biomass weight, including sorghum studies in the U.S.A and other parts or the world in the past 30 years.

Generally, the increased rates of N, and P increased the plant grain yield and biomass (Table 2). This might be the attributes of N and P role which mean nitrogen is an important component of major structural, genetic, and metabolic compounds in plant cells, including chlorophyll, amino acids, and nucleic acids and phosphorus is also a vital component of: DNA, RNA, and ATP which is essential for the general health and vigor of all plants. Adequate P nutrition is critical for root development, increased stalk and stem strength, increased flowering and seed production, uniform and early crop maturity, improved crop quality, and increased resistance to plant diseases these all resulted in increasing of grain yield and biomass weight of the sorghum, this research findings trend is in agreement with investigation of (Bayu *et al*., 2006) on sorghum, in the same way, Pholsen and Somsungnoen (2005) reported that also an increase in N and K rates significantly increased most growth parameters of sorghum plants which enhances high biomass production.

Sorghum lodging and Sorghum with heading

The most obvious losses occur when plants lodge, however recent advances in harvesting equipment have helped a great deal in recovering grain from lodging. These losses are caused by reduced ear and head size, poor filling of grain, and early eardrop or head lodging as plants mature early. As shown in table 1 the highest lodging (24.667) was recorded at control treatment (0/0) application of inorganic fertilizer nitrogen and phosphorus whereas on the contrary of this the least lodging (2.667) was recorded at the highest application of N-P fertilizer (92, 30) and there was continuous declining of lodging when the application of N-P nutrients increases; between treatments it is also shown that statistically significantly different (table 2 and table 3). This might be due to the presence of nutrient status of the soil/the application of different rate of the most important limiting macro-essential especially fertilizer nutrients can influence the plant lodging negatively /positively dramatically. This research findings is in lined with the report of Fedenko *et al*. (2015) who indicated as the severity of lodging is impacted by a range of factors including; varietal susceptibility/genetic agents and environmental factors, the effects of nutrients like nitrogen and phosphorus on growth, development, yield and yield components of sorghum can be observed significantly, similarly Esechie (1983) reported that any nutrient deficiency, which stresses the sorghum crop can lead to lodging, not only this but also lodging can reduce grain yield, soluble stem sugars, and recoverable biomass which implies that whole plant could be affected (Fedenko *et al*., 2015).

Though the amount/number of sorghum with headings wasn't statistically significantly different between the treatments at ($P \leq 0.01$) and ($P \leq 0.05$), the amount of headings of sorghum was affected differently by the main effect of applied rates of inorganic N-P fertilizers (Table 1 and table 2). Sorghum with headings increased consistently with increasing rates of application of inorganic N-P fertilizers from 58 in the control (0/0 N/P) treatment to 121.67 in the treatment of (92, 30). This might be attributed to large quantities of nitrogen and phosphorus are translocated from the other plant parts to the grain as it develops heads. Unless adequate nutrients are available during grain filling this translocation may cause deficiencies in the leaves and premature leaf loss which may decrease yields. This research result is in lined with the findings of Ciampitti *et al.,* (2014) who revealed that as adequate supply of N-P nutrients at all stages of development of the plant are necessary for maximum heads which resulted in maximum yield production and similarly Dahlberg *et al*., (2013) reported that adequate N and P is needed to produce maximum heads and yield production. Moreover, the non-statistically significant difference between the treatments of different application rate of inorganic N-P fertilizers on sorghum might be the attributes of certain head diseases of grain sorghum can result in severe production problems which is in agreement with the research findings of (Robinson *et al*., 1977, Oplinger, 1973 and Oelke, 1971**)** who stated that diseases cause a reduction of head and grain fill through direct attack of inflorescences by disease organisms.

Summery

Nutrient application of plants could be different from site to site depending on different factors soil nutrient status and the like. For sustainable production of plant/crops for a specific area, specific fertilizer reference is very decisive this is owing to the production of any crops/plants yield could be influenced by nutrients status of the soil in addition to genetic factors. To do this and to come up with a certain solution, a field experiment was conducted in Derashe woreda, Sagan peoples zone, SNNPR, Ethiopia in 2013/14. The experiment was aimed to carry out to determine the optimum rate of fertilizer of N-P for Arguba Keble, Derashe woreda, Sagan Peoples zone, SNNPR, Ethiopia and to determine the yield and yield components of sorghum by application of different rate of N-P inorganic fertilizers for Arguba, Derashe woreda, SNNPR, Ethiopia. The treatments consisted of combination of five levels of phosphorus and nitrogen (0/0, 23/10, 46/20, 69/30 kg, 92/30 ha^{-1}) on sorghum crop. The twenty treatment combinations were replicated three times in factorial RCBD design. The yield and yield components of the sorghum crop were detected to respond to impacts of inorganic macro-essential N-P fertilizer nutrients. Parameters, such as, plant lodging , weight of biomass, and grain yield, were statistically significantly different by nitrogen and phosphorus different fertilizer rates whereas plant height and plant with heading weren't statistically significant but showed continuous increasing with increasing N-P fertilizer application. Hence, N and P fertilizers are very vital nutrients in restricting the growth, development and productivity of land and as well the production of the crops. The future studies should articulate towards and studies' involving more varies, multi-location and additional rates of N and P application, under diverse management practices, which may facilitate fine-tuning of fertilizer recommendations. Hence, the forthcoming investigations ought to focus on the way to the investigations encompassing, different agro-ecology and additional rates of nitrogen and phosphorus applications, under different management practices such as research and farmer's field's normal conditions, which perhaps enable pave the way for fertilizer recommendations for this specific sorghum crop for Derashe woreda.

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References

Azrag, A. A. D, and Dagash, Y, M .I. 2015. Effect of Sowing Date and Nitrogen Rate on Growth, Yield Components of Sorghum (Sorghum Bicolor L.) and Nitrogen Use Efficiency, Journal of Progressive Research in Biology (JPRB ISSN 2454-1672)

Bayu, W., Rethman, N.F.G., Hammes, P.S. and Alemu, G. (2006) Effects of Farmyard Manure and Inorganic Fertiliz- ers on Sorghum Growth, Yield, and Nitrogen Use in a Semi-Arid Area of Ethiopia. Journal of Plant Nutrition, 29, 391- 407. http://dx.doi.org/10.1080/01904160500320962

Bumb, B.I. and Bannante, C.A. (1996) The Use of Fertilizer in Sustaining Food Security and Protecting the Environ- ment-2020. Proceedings of Conference on Agriculture and Fertilizer Use by 2010, NEDC, Islamabad, 35

Ciampitti, I.A., Diaz, D.R, and et al. 2014. Kansas Sorghum Management 2014. Kansas State Research & Extension Bulletin MF3046.

CSA (Central Statistics Authority), 2000. Central Statistics Bulletin No 245, pp 83-125. Ethiopia, Addis Ababa.

Dahlberg, J and et al. 2013. United Sorghum Program's West Texas Production Handbook. United Sorghum Checkoff Program.

Elasha, E.A (2007). Trials at Gezira Research Station. Sorghum Research Program – Annual report 2006 / 2007

FAO (Food and Agricultural Organization of the United Nations), 1995. Integrated plant nutrition System. Dudal R. and Roy, R.N. (Eds.) FAO Fertilizer and Plant Nutrition Bull. No. 12. Plant Nutrition Management Service, FAO Land and Water Development Division. Rome, Italy

Grain Sorghum Production Handbook. 1987. Bulletin C-687, Cooperative Extension Service, Kansas State University.

H. A. Esechie (1983). Relationship between lodging, certain morphological characters and yield of grain sorghum (Sorghum bicolor L. Moench). *The Journal of Agricultural Science*, 101, pp. 669-673. doi:10.1017/S0021859600038697.)

Jeffrey R. Fedenko, John E. Erickson, and Maninder P. Singh (2015). Root lodging affects biomass yield and carbohydrate composition in sweet sorghum; *journal of Industrial Crops and Products,* Volume 74, 15 November 2015, Pages 933–938

Kansas State University Agricultural Experiment Station and Cooperative Extension Service. 2006. Stalk Rots of Corn and Sorghum

Martin, J.H. and W.H. Leonard, 1987. Principles of field crops production.2 nd Ed. The Macmillan Company, Collier-Macmillan Limited, London.

Mesfin Kassa, Zemach Sorsa. Effect of Nitrogen and Phosphorus Fertilizer Rates on Yield and Yield Components of Barley (Hordeum Vugarae L.) Varieties at Damot Gale District, Wolaita Zone, Ethiopia. American Journal of Agriculture and Forestry. Vol. 3, No. 6, 2015, pp. 271-275. doi: 10.11648/j.ajaf.20150306.15

MOA (Ministry of Agriculture), 1998. Agro-ecological Zones of Ethiopia. Natural Resources Management and Regulatory Department (with support of German Agency for Technical Cooperation (GTZ), Ministry of Agriculture, Addis Ababa, Ethiopia.

Mohamed, G.G (1990). The effect of nitrogen and phosphorus fertilizers on growth and yield of some Grasses and leguwimous Forage. Msc. Thesis of Agric. University of Khartoum, Suda

Oelke, E.A. 1971. Grain Sorghum in Minnesota. Crop News No. 12, Agronomy and Plant Genetics, Univ. of Minn.

Onyango, R.M., T.K. Mwangi, W.W. Kiya and M.K. Kamidi, 1998. Maintaining soil productivity by combining organic and inorganic fertilizers in smallholder farms within the Kitale Region in Kenya. Proceedings of the 6 the Eastern and southern Africa Regional Maize Conference. 21 st -25 th Sept, 1998. pp. 242-246.

Oplinger, E.S. 1973. Grain Sorghum Production in Wisconsin. Field Crops 24A. Univ. of Wis. Agronomy mimeo. 8p.

Pholsen, S. and Sormsungnoen, N. (2005) Effects of Nitrogen and Potassium Rates and Planting Distances on Growth, Yield and Fodder Quality of a Forage Sorghum (Sorghum bicolor L. Moench). Pakistan Journal of Biological Sciences, 7, 1793-1800

Prasad, B. and A.P. Singh, 1980. Changes in soil properties with long term use of fertilizer, lime and farm yard manure. J. Indian Soc. Soil Sci. 28(4) 465-468

Regessa Kumssa. 2005. Effects of Integrated Use of Decomposed Coffee Husk and Inorganic N and P Fertilizers on Yield and Yield Related Parameters of Sorghum on Nitisols of Jimma Area, Ethiopia, MSc thesis

Robinson, R.G., W.W. Nelson, J.H. Ford, and D.P. Warnes. 1977. Drought and Grain Sorghum. Misc. Report 147, Minnesota Agr. Exp. Station.

Shrotriya, G.C. (1998) Balanced Fertilizer—India Experience. Proceedings of Symposium on Plant Nutrition Manage- ment for Sustainable Agricultural Growth, NFDC, 8-10 December 1997, Islamabad.

Tekalign Mamo and Haque, I. 1991. Phosphorus Status of Some Ethiopian Soils. III. Evaluation of soil test methods for available phosphorus. *Tropical Agriculture*(Trinidad) 68: 51-56.

Taye Bekele, 1996. Integrated plant nutrition system. Proceedings of the Third Conference of Ethiopian Society of Soil Sciences. Pp-119-127. February 28-29, 1996. Addis Ababa, Ethiopia

Taylor, R. W. (ed). 1988. Grain Sorghum: A Manual for Production and marketing. Extension Bulletin 148, Delaware Cooperative Extension.

Turnquist, P. K. and Matter, V. E., "Header Attachments Help Save Grain Sorghum at Harvest" (1967). *Bulletins.* Paper 542)

Yousf, B. M (1993). The Response of some sorghum cultivars to nitrogen fertilization at two sowing dates – thesis of Msc- University of Gezira – Faculty of Agricultural Sciences.