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Effect of Nitrogen and Phosphorus Fertilizer Rates on Yield and Yield Components Sorghum (*Sorghum bicolor* L. Moench) at Kersa Woreda of Oromia Region

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Abstract: Soil fertility is among the most important constraints that threaten sorghum production in Jimma Zone in Oromia Region. Therefore, a field experiment was carried out at Kersa woreda for four consecutive cropping seasons from 2013/14 to 2016/17 to evaluate the response of various levels of nitrogen (N) and phosphorus (P) fertilizer using sorghum. The treatments consisted of factorial combinations of four rates each of N (0, 23, 46 and 69 kg N ha^{-1}) and P (0, 11.5, 23 and 34.5 kg P_2O_5 ha^{-1}) laid down in a randomized complete block design (RCBD) with three replications. For data analysis, correlation coefficient and ANOVA were used. The result showed that the yield and yield components of the sorghum crop were highly significant response to impacts of inorganic N-P fertilizer nutrients. Parameters, such as, plant height, head weight, grain yield, biomass yield and stover yield, were statistically significantly different by nitrogen and phosphorus different fertilizer rates. Also, these parameters were significant and positive correlation to each other. This result revealed that the highest (4.14t/ha) grain yield was obtained from $69kgh^{-1}$ N and $23kgha^{-1}$ P_2O_5 inorganic fertilizer, whereas the lowest (1.37t/ha) grain yield was recorded from control treatment. Compared to the control treatment, the highest rate of N/P (69/23 kg ha^{-1}) increased sorghum grain yield by about 202.2%. It is concluded that nitrogen and phosphorus at the rate of $69kgh^{-1}$ N and $23kgha^{-1}$ P_2O_5 has the best performance in obtaining maximum grain yield of sorghum crop. Therefore, N-P at the rate of $69kgh^{-1}$ N and $23kgha^{-1}$ P_2O_5 is highly recommended for optimum grain yield of sorghum crop in the study area.

Keywords: Fertilize, Grain Yield, Nitrogen, Phosphorus, Sorghum

1. Introduction

Globally, sorghum (*Sorghum bicolor* L. Moench) is the fifth most vital rice, wheat, barley and cereal crop after maize [5]. It is an important crop staple food crop in the semi-arid tropics of Africa, south Asia and Central America [10]. In Ethiopia, sorghum is a major staple food crop, ranking second after maize in total production. It ranks third after wheat and maize in productivity per hectare, and after Teff and maize in area cultivated. It is grown in almost all regions, covering a total land area of 1.8 million ha [3]. Sorghum grain is as nutritious as other cereal grains; contains about 11% water, 340 k/cal of energy, 11.6% protein, 73% carbohydrate and 3% fat by weight [18, 19].

Despite the large-scale production and various merits, Sorghum production and productivity have been far below the potential. Currently the average regional productivity is 2.1t ha^{-1} but, the study area productivity is below 1.3 t ha-1 which is very low as compared to other small grain cereals grown in Ethiopia [3]. Low productivity of crops has been attributed to abiotic stress for drought and low soil fertility and biotic stress for the disease, insect and weeds [15, 12].

Soil fertility is one of the major production constraints in the Ethiopia. Deficiency of nitrogen and phosphorus is the main factor that severely reduces the yield of sorghum [2]. According to [1], although soil fertility status is dynamic and variable from locality to locality, and it is difficult to end up with a blanket recommendation invariably, some soil amendment studies were undertaken at different times and places. In addition to fertilizer rates, soil acidity also affects the productivity of the land by affecting availability of nutrients and hindering the activity of microorganisms. Also nitrogen is commonly the most limiting nutrient for crop production in the major world's agricultural areas and therefore adoption of good N management strategies often result in large economic benefits to farmers. The various factors accounting for the poor soil fertility include topography, soil erosion, deforestation, population pressure, and continuous cultivation without proper soil fertility maintenance [8, 9, 14]. Among the major constraints on increased production of sorghum are poor soil fertility, limited supply of production inputs, low prices for the produce, and undeveloped markets [15]. The application of inorganic P fertilizer increased the efficient utilization of inorganic N fertilizer by the plants in grain yield and total biomass production; also, P nutrition of soils is critical for the efficient use of inorganic N fertilizer, thus deficiency in soil P limited the efficient use of applied N by the plant [20]. There was limited research conducted concerning fertilizers rates as a result of this fact, the farmers rely on traditional practices. Most of the farmers in experiment site do not use NP combination above the recommended rate. Therefore, there is a need to study the effect of different NP rates on the yield and yield components of sorghum.

2. Materials and Methods

2.1. Description of the Study Area

The experiment was conducted at Kersa woreda, Jimma zone of the Oromia national state for four consecutive cropping seasons from 2013/14 to 2016/17. The site is located at about 28 km east from Jimma town and 7° 40′ 0″ N latitude and 36° 50′ 0″ E longitude at an average elevation of 1740 to 2660 m amsl and average maximum and minimum temperature is 28.8°C and 11.8°C respectively and reliably receives good rains, ranging from 1,200 – 2,800 mm per annum cropping season. The middle and high altitude soils are less rich in nutrients due to the fact that they have been under human land use for long. The zone is one of the major coffee growing areas of Oromia region well-endowed with natural resources contributing significantly to the national economy of the country. The major crops grown, other than coffee, are maize, teff, sorghum, barley, pulses (beans and peas), root crops (enset-false banana and potato) and fruits.

2.2. Description of the Experimental Materials

Plant materials: In the present study, Sorghum varieties Abamelko which adapted to the agro-ecology of the area were used. Varieties Abamelko is the most promising released by Jimma Agricultural Research Centre. It has wider adaptability and grows well at altitudes ranging from 1740 to 2660 meters above sea level with annual rain fall of 1,200 – 2,800 mm.

2.3. Experimental Design and Treatments

The experiment was conducted in Kersa district of Oromia Region in 2013/204 to 2016/2017 cropping seasons. The treatments consisted of four N levels (0, 23, 46 and 69 kg N ha^{-1}) and four P levels (0, 11.5, 23 and 34.5 kg P_2O_5 ha^{-1}). The experiment was arranged in randomized complete block design (RCBD) with three replications in a factorial arrangement. The plot size was $14.25m^2$ (3.75 m × 4 m) and consisted of 5 rows. A distance of 0.5 m and 1 m were left between plots and blocks, respectively. The spacing of 75 × 15 cm was used between rows and plants, respectively and there were 26 plants planted per row with a total of 133 plants per plot. Urea and Triple supper phosphate (TSP) were used as a source nitrogen and phosphorus fertilizer, respectively. Nitrogen fertilizer was applied by split; application method in the form of urea half at planting and the remaining 45 days after planting. Phosphorus was applied once in the form of TSP at the time of planting. Agronomic practices such as weeding and cultivation were done uniformly for all treatments as per need.

2.4. Data Collection and Measurement

Plant height (cm) was measured at physiological maturity from the ground level to the tip of head from ten randomly taken plants and was averaged on per plant basis. Head weight (g): samples of ten heads were weighed after harvesting and sun drying to determine weight per head. Weight was adjusted to 12.5% moisture level. Grain and stover yields (t/ha) were determined by harvesting the entire net plot area and converted into tons per hectare. Grain yield was adjusted to 12.5% moisture level; whereas stover yield was weighed after leaving it in open air for 7 days. The biomass yield (t/ha) was calculated as the sum of the grain and stover yields.

2.5. Data Analysis

Collected data were subjected to analysis of variance (ANOVA) by using Statistical Analysis System Software Version 9.3 [16] and significant treatment means was separated using Least Significance Difference (LSD) test and correlation coefficient within and between yield and agronomic parameters was done.

3. Results and Discussion

3.1. Effect NP Fertilizer Combination on Plant Growth, Yield and Yield Components Sorghum

Plant height

The mean of plant height and the analysis of variance are shown in (Table 1). There were highly significant variations ($p \le 0.001$) among the fertilizers types on sorghum height. The Application of NP fertilizer linearly and significantly increased plant height as compared to the control (no application any fertilizer). Similarly, the highest mean value (197.42cm) was obtained from the application of 69kg ha^{-1} N and 34.5kg ha^{-1} P_2O, while the lowest mean value (157.57cm) was recorded from the control treatment (Table 1). The treatment increased mean value of plant height by about 25.29% as compared with unfertilized plots. Plant height was significant and positive correlation with stover yield (Table 6). This result suggests that Plant height increased with increasing application of NP fertilizer rates.

The possible reason for the increased plant height of sorghum over the control in response to the mixed application of the fertilizers might be attributed to the released major nutrients and improved soil physical property in enhancing plant growth owing to their contribution to enhanced cell division, stem elongation, promotes leaf expansion and vegetative growth of plant. This result is in agreement with [11] who reported that plant height of sorghum was increase with increasing rates of NP from 0/0 to 69/46 kg ha^{-1}. This study is in agreement with [17] who reported that application of NP fertilizer at rate 49/46 $kgha^{-1}$ significantly increases the plant height of sorghum, and height of sorghum was 18.21cm greater than control treatment at rate 69 kg N and 46 P_2O_5 ha^{-1} fertilizer. It can be concluded the increased rates of N, and P increased the plant growth and biomass, and also the increased amounts of N-P increases the production of sorghum crop [4].

Table 1. *Effect of nitrogen and phosphorus fertilizer rates on sorghum height.*

Treatment (NP)	Plant height (cm)				
	2013/2014	2014/2015	2015/2016	2016/2017	Over year
0/0	171^{f}	1.32^{e}	149^{h}	177.93^{e}	157.57^{i}
0/11.5	178^{ef}	135^{e}	156^{h}	179.33^{e}	162.16^{i}
0/23	184^{edf}	140^{de}	165^{g}	197.80^{cab}	171.72^{h}
0/34.5	190^{cedb}	153^{cdb}	$169g^{f}$	181.38^{de}	173.51^{hg}
23/0	186^{cedf}	146^{cde}	168^{g}	188.80^{cde}	172.12^{h}
23/11.5	192^{cedb}	159^{cba}	169^{gf}	195.07^{cb}	178.57^{hfg}
23/23	200^{cadb}	155^{cdb}	$170g^{ef}$	197.71^{cab}	180.54^{defg}
23/34.5	206^{ab}	156^{cdba}	178^{dec}	200.53^{cab}	185.02^{debfc}
46/0	190^{cedb}	160^{cba}	176^{def}	192.78^{cdb}	179.56^{efg}
46/11.5	202^{cab}	154^{cdb}	177^{def}	194.89^{cb}	181.78^{defc}
46/23	202^{cab}	167^{ab}	185^{bc}	190.67^{cdbe}	186.08^{debc}
46/34.5	206^{ab}	163^{ab}	181^{dbc}	198.56^{cab}	186.93^{dbc}
69/0	203^{cab}	164^{ab}	184^{dbc}	200.36^{cab}	187.76^{bc}
69/11.5	207^{ab}	166^{ab}	188^{ba}	187.67^{cde}	187.16^{dbc}
69/23	209^{a}	167^{ab}	189^{ba}	202.62^{ab}	191.99^{ba}
69/34.5	213^{a}	171^{a}	196^{a}	209.78^{a}	197.42^{a}
LSD (0.05)	17.4	16.03	6.18	13.332	7.1082
CV (%)	5.32	6.18	2.81	4.13	2.36

Values followed by the same letter within a column are not significantly different at P< 0.05

Head weight

Head weight was highly significantly affected ($p \leq 0.001$) by different rates of NP application (Table 2). The results indicated that head weight was linearly increased with increasing levels of NP fertilization from 0/0 to 69/23 kg NP_2O_5 ha^{-1}. The maximum head weight (93.17gm) was recorded from application of 69/23 kg NP_2O_5 ha^{-1}, whereas zero the minimum (29.13gm) was obtained zero application, which was significantly lower than the effect of other rates. Thus, the combination of N and P at 69/23 kg ha^{-1} resulted in about 219.7% higher head weight compared with the application of no fertilizer (Table 2).

This might be attributed to large quantities of nitrogen and phosphorus is translocated from the other plant parts to the grain as it develops heads. This current result is in agreement with [13] who indicated that Sorghum with headings increased consistently with increasing rates of application of inorganic N-P fertilizers from 58 to 121.67. In the same way, head weight was significant and positive correlation with grain yield (Table 6). The present study is similar to the findings of [6] who reported that head weight had the highest direct effect on grain yield sorghum, and also there is significant and high positive correlation between grain yield and head weight (r=0.976).

Grain yield

Application of nitrogen and phosphorus fertilizers highly significantly ($p \leq 0.001$) influenced grain yield. Mean values of the data showed that maximum grain yield (4.14 t/ha) was produced by the treatments of 69/23 kg ha^{-1} NP inorganic fertilizers. However, the control plots resulted in minimum grain yield (1.37 t/ha) (Table 3). Compared to the control treatment, the highest rate of N/P (69/23 kg ha^{-1}) increased sorghum grain yield by 202.2%. Hence, application of 69/23 N and P fertilizer rate gave the highest sorghum yield all years (Table 4). Also, grain yield was significant and positive correlation growth parameters, yield and yield components of sorghum (Table 6).

Similar result was observed in [17] that there is significant increase in grain yield of sorghum when supplied with higher rates of NP fertilizer. This result is in agreement with [13] who reported that application of 92/30 kg ha^{-1} NP fertilizer rate increased the grain yield of sorghum. Also, this study is in agreement with the finding of [20] who stated that increasing N rates significantly increased grain and total dry biomass production, whereas the application of inorganic P fertilizer increased the efficient utilization of inorganic N fertilizer by the plants in grain yield and total biomass production.

Total biomass yield

The total biomass yields of sorghum were highly significantly ($p \leq 0.001$) affected by inorganic N-P fertilizers rates (Table 4). Total biomass yield was increased with applying NP fertilizers. Accordingly, the maximum mean total biomass yield (10.27t/ha) of sorghum was recorded from application of 69/23 NP fertilizer, while the lowest mean total biomass yield (3.52 t/ha) of sorghum was recorded from control without application of any fertilizer (Table 4). The current result indicated that NP fertilizer increased the biomass yield by 191.76% over control treatments.

The maximum mean total biomass yield recorded from 69/23 NP over the control might be due to more nutrients gained from both NP combined fertilizers. The result was in line with [17] who reported that application of NP fertilizer at rate 69/46 kg ha^{-1} increases the grain yield of sorghum significantly. In the same way, study conducted by Masebo and Menamo (2016) observed that NP fertilizer application at rate 92/30 kgha^{-1} increases the total biomass yield of sorghum by 68.21% advantage over control treatment. This current study is supported by [20] who reported that the application of inorganic P fertilizer increased the efficient utilization of inorganic N fertilizer by the plants in grain yield and total biomass production; also, P nutrition of soils is critical for the efficient use of inorganic N fertilizer, thus deficiency in soil P limited the efficient use of applied N by the plant.

Table 2. *Effect of nitrogen and phosphorus rates on head weight of sorghum.*

Treatment (NP)	Head Weight (t/ha)				
	2013/2014	2014/2015	2015/2016	2016/2017	Over year
0/0	25.43^{j}	21.1^{d}	43.16^{g}	26.85^{e}	29.13^{e}
0/11.5	33.13^{ij}	21.7^{cd}	46.01^{fg}	34.76^{de}	33.90^{e}
0/23	35.19^{ihj}	41.44^{cbd}	47.74^{fg}	48.26^{cde}	43.16^{de}
0/34.5	39.48^{ihfgj}	51.91^{cabd}	62.28^{efg}	59.87^{cdbe}	53.39^{dc}
23/0	38.31^{hgj}	55.18^{cabd}	67.80^{ed}	52.83^{cde}	53.53^{dc}
23/11.5	41.99^{iehfg}	56.42^{cabd}	64.64^{efd}	57.76^{cdbe}	55.20^{dc}
23/23	48.07^{ehfgd}	60.04^{ab}	82.50^{cd}	72.77^{cba}	65.84^{bc}
23/34.5	53.84^{ed}	60.77^{ab}	81.40^{ecd}	63.65^{cdba}	64.91^{bc}
46/0	44.15^{iehfgd}	55.79^{cabd}	97.31^{cb}	74.35^{cba}	67.90^{bc}
46/11.5	50.67^{ecfgd}	60.21^{ab}	88.84^{c}	57.94^{cdbe}	64.41^{bc}
46/23	82.89^{a}	79.79^{a}	116.41^{ab}	90.35^{ba}	92.36^{a}
46/34.5	57.29^{cd}	60.93^{ab}	115.88^{ab}	75.57^{cba}	77.42^{ba}
69/0	56.79^{cd}	58.79^{cab}	82.57^{cd}	67.9^{cdba}	66.51^{bc}
69/11.5	52.90^{ecfd}	80.15^{a}	116.59^{ab}	79.23^{cba}	82.22^{ba}
69/23	75.79^{ab}	83.27^{a}	118.58^{a}	95.06^{a}	93.17^{a}
69/34.5	62.40^{ab}	83.41^{a}	89.72^{c}	73.95^{cba}	77.37b^{a}
LSD (0.05)	14.31	37.524	19.321	33.431	18.565
CV (%)	17.2	38.67	14.02	31.11	17.45

Values followed by the same letter within a column are not significantly different at $P < 0.05$.

Table 3. *Effect of nitrogen and phosphorus rates on grain yield of sorghum.*

Treatment (NP)	Grain Yield (t/ha)				
	2013/2014	2014/2015	2015/2016	2016/2017	Over year
0/0	1.40^{j}	1.42^{h}	1.56^{i}	1.30^{f}	1.37^{h}
0/11.5	1.88^{ij}	1.50^{h}	1.74^{i}	1.41^{ef}	1.47^{h}
0/23	2.01^{ij}	1.51^{h}	2.33^{h}	1.63^{def}	1.90^{g}
0/34.5	2.28^{hifjg}	2.35^{g}	2.58^{hg}	2.50^{cadbef}	2.55^{fe}
23/0	2.21^{hijg}	2.63^{gf}	2.85^{fg}	1.93^{cdef}	2.46^{f}
23/11.5	2.44^{heifg}	2.63^{gf}	2.98^{f}	2.57^{cdbe}	2.76^{fed}
23/23	2.82^{hefdg}	2.66^{gfe}	3.01^{fe}	2.68^{cadb}	2.81^{fed}
23/34.5	3.19^{ecd}	3.03^{dfe}	3.07^{fe}	2.26^{cdbef}	2.83^{ed}
46/0	2.58^{heif}	3.10^{cdfe}	3.09^{fe}	2.62^{cadbe}	2.95^{d}
46/11.5	2.99^{ecfdg}	3.22^{cdbe}	3.29^{de}	2.33^{cdbef}	2.98^{d}
46/23	5.01^{a}	3.68^{ba}	4.31^{a}	3.40^{ab}	3.95^{ba}
46/34.5	3.40^{cd}	3.52^{cdba}	3.46^{dc}	3.04^{cab}	3.53^{c}
69/0	3.37^{cd}	3.52^{cdba}	3.59^{c}	2.97^{cab}	3.35^{c}
69/11.5	3.13^{ecfd}	3.43^{cdba}	4.14^{ba}	3.26^{cab}	3.52^{c}
69/23	4.57^{ab}	3.80^{a}	4.33^{a}	3.56^{a}	4.14^{a}
69/34.5	3.72^{cb}	3.66b^{a}	4.01^{b}	2.62^{cadb}	3.61^{bc}
LSD (0.05)	0.9013	0.5747	0.2877	1.2097	0.3636
CV (%)	18.39	12.07	5.48	28.96	7.55

Values followed by the same letter within a column are not significantly different at $P < 0.05$.

Table 4. *Effect nitrogen and phosphorus rates on total biomass yield of sorghum.*

Treatment (NP)	Total Biomass Yield (t/ha)				
	2013/2014	**2014/2015**	**2015/2016**	**2016/2017**	**Over year**
0/0	4.30^{i}	3.45^{f}	5.90^{i}	3.17^{c}	3.52^{g}
0/11.5	5.07h^{i}	4.06^{ef}	6.18^{i}	3.65^{c}	4.07^{fg}
0/23	5.89^{ghfi}	4.27^{def}	6.95^{h}	6.42^{bc}	5.07^{efg}
0/34.5	6.61^{ghf}	6.15^{dec}	7.78^{g}	7.68^{bc}	6.13^{edf}
23/0	6.38^{ghfi}	6.42^{dc}	7.87^{g}	6.75^{bc}	6.00^{edf}
23/11.5	6.42^{ghfi}	6.92^{bc}	8.52^{f}	8.80^{ba}	6.69^{ed}
23/23	7.79^{gdfe}	7.26^{abc}	9.73^{e}	9.05^{ba}	7.26^{edc}
23/34.5	10.09^{cab}	7.71^{abc}	10.04^{de}	7.70^{ba}	7.64^{dbc}
46/0	5.763^{ghi}	7.83^{abc}	10.14^{de}	9.13^{ba}	6.99^{edc}
46/11.5	6.793^{ghe}	7.90^{abc}	10.56^{dc}	7.47^{ba}	6.91^{edc}
46/23	12.20^{a}	8.79^{ab}	12.82^{a}	10.60^{ba}	9.70^{ab}
46/34.5	8.85^{cdbe}	8.92^{ab}	10.88^{c}	9.38^{ba}	8.36^{adbc}
69/0	7.94d^{fe}	8.93^{ab}	10.89^{c}	9.08^{ba}	8.17^{adbc}
69/11.5	8.033^{dfe}	8.92^{ab}	12.06^{a}	12.92^{a}	9.23^{abc}
69/23	10.323^{ab}	9.40^{ab}	13.10^{a}	13.34^{a}	10.27^{a}
69/34.5	9.61^{db}	9.16^{ab}	13.07^{a}	9.81^{ba}	9.12^{abc}
LSD (0.05)	2.154	2.335	0.4632	36.17	2.4202
CV (%)	16.93	19.30	2.84	5.0874	20.17

Values followed by the same letter within a column are not significantly different at P< 0.05.

Table 5. *Effect of nitrogen and phosphorus rates on stover yield of sorghum.*

Treatment (NP)	Stover Yield (t/ha)				
	2013/2014	**2014/2015**	**2015/2016**	**2016/2017**	**Over year**
0/0	6.47^{d}	2.03^{d}	4.33^{i}	1.87^{e}	3.58^{g}
0/11.5	6.55^{cd}	2.56^{cd}	4.44^{i}	2.24^{de}	3.85^{fg}
0/23	6.71^{cd}	2.75^{cbd}	4.62^{i}	4.78^{cde}	4.61^{feg}
0/34.5	6.80^{cd}	3.80^{cabd}	5.20^{hg}	5.18^{cde}	5.13^{fdeg}
23/0	6.80^{cd}	3.79^{cabd}	5.02^{h}	4.82^{cde}	4.99^{fdeg}
23/11.5	6.74^{cd}	4.28^{cab}	5.53^{g}	6.23^{cdba}	5.57^{cfde}
23/23	6.78^{cd}	4.60ab	6.73^{f}	6.37^{cdba}	5.97^{cdeb}
23/34.5	6.94^{cd}	4.68^{ab}	6.97^{fe}	5.44^{cdbe}	5.85^{cdeb}
46/0	6.76^{cd}	4.72^{a}	7.06^{fed}	6.51^{cba}	6.10^{cdeb}
46/11.5	6.84^{cd}	4.68^{ab}	7.27^{ed}	5.14^{cde}	5.82^{cdeb}
46/23	8.22^{cab}	5.11^{a}	8.51^{b}	7.20^{cba}	7.07^{cab}
46/34.5	8.10^{cabd}	5.40^{a}	7.42^{d}	6.34^{cdba}	6.64^{cadb}
69/0	7.06^{cd}	5.42^{a}	7.30^{ed}	6.11^{cdba}	6.31^{cadeb}
69/11.5	7.14^{cbd}	5.48^{a}	7.92^{c}	9.66^{ba}	7.37^{ab}
69/23	8.85^{ab}	5.61^{a}	8.76^{ba}	9.78^{a}	8.05^{a}
69/34.5	9.05^{a}	5.50^{a}	9.06^{a}	7.19^{ba}	7.49^{ab}
LSD (0.05)	1.7274	1.9371	0.3709	4.2371	1.7831
CV (%)	14.31	26.39	3.35	42.86	18.12640

Values followed by the same letter within a column are not significantly different at P< 0.05.

Stover yield

The stover yield of sorghum was showed highly significant ($p \leq 0.001$) difference due to treatments (Table 5). Accordingly, the maximum stover yield (8.05t/ha) of sorghum was recorded from application of 69/23 $kgha^{-1}$ NP inorganic fertilizer, while the lowest stover yield (3.58t/ha) of sorghum was obtained from the unfertilized plot. This 69/23 $kgha^{-1}$ NP treatment gave stover yield advantage of 4.47 t/ha (124.86%) compared to unfertilized plots (Table 5).

This indicates that presence of greater stover yield of sorghum might be due to the fact that crops supplied with adequate nutrients have more vegetative growth, longer linear growth rate and more dry matter accumulation which directly related to an increment in stover yield. This result is supported by [17] who reported that application of nitrogen with phosphorus increase on plant height, grain yield and biomass yield of sorghum. The increase in stover yield with higher N levels might be due to the increase in grain and total dry biomass of maize with higher N rates [20].

3.2. Correlation Between Growth Parameters, Yield and Yield Components of Sorghum

A summary of the correlation coefficients of the relationships between selected growth parameters, yield and yield components of sorghum in kersa woreda farmers farm, are presented in Table 6. Accordingly, the result indicates all selected parameters of sorghum were significant and positive correlation with one another. Hence, this result suggests that, sorghum grain yield, plant height, head weight, total biomass yield and stover yield is highly influenced NP inorganic fertilizer. The current study is in agreement with [6] who revealed that there was significant and positive correlation between grain yields, head weight and 1000 grain mass, whereas significant but negative correlation exists between panicle count and panicle length.

Table 6. *Pearson correlation coefficients between selected sorghum plant parameters.*

Sorghum Plant Parameters	PH	HW	GY	TBMY	STY
PH	1				
HW	0.39*	1			
GY	0.46**	0.91**	1		
TBMY	0.37*	0.94**	0.90**	1	
STY	0.35*	0.91**	0.85*	0.97**	1

** = $P \leq 0.001$; * = $P \leq 0.05$; PH= plant height; HW= head weight; GY= grain yield; TBMY= total biomass yield.

4. Conclusion

Overall, the present study showed that the yield and yield components of the sorghum crop were significant response to impacts of inorganic N-P fertilizer nutrients. Parameters, such as, plant height, head weight, grain yield, biomass yield and stover yield, were statistically significantly different by nitrogen and phosphorus different fertilizer rates. Also, these parameters were significant and positive correlation to each other. Therefore, N and P fertilizers are very vital nutrients in limiting the growth, development and the production of the crops in the study area.

This result revealed the highest (4.14t/ha) grain yield was obtained from $69kgh^{-1}$ N and $23kgha^{-1}$ P_2O_5 fertilizer, whereas the lowest (1.37t/ha) grain yield was recorded from control treatment. Compared to the control treatment, the highest rate of N/P (69/23 kg ha^{-1}) increased sorghum grain yield by about 202.2%. It is concluded that nitrogen and phosphorus at the rate of $69kgh^{-1}$ N and $23kgha^{-1}$ P_2O_5 has the best performance in obtaining maximum grain yield of sorghum crop. Therefore, N-P at the rate of $69kgh^{-1}$ N and $23kgha^{-1}$ P_2O_5 is highly recommended for optimum grain yield of sorghum crop in the study area.

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