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Research Article

Effect of Cattle Manure and Crop Residue on Yield and Yield Components of Maize (*Zea mays* L.) under Supplementary Irrigation at Uke, Western Ethiopia

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ABSTRACT

Maize is one of Ethiopia's major and strategic cereal crops, albeit the national average yield remains low. The contribution of inorganic fertilizer to enhance crop growth and yield cannot be ignored, but on the other hand their indiscriminate use is causing deterioration of the soil structure and soil acidity. A field experiment was conduct at 2020 under supplementary irrigation at Guto Gidda district, Western Ethiopia, to study the effect of variable rate of cattle manure and crop residue on the growth, and yield and yield components of maize (*Zea mays* L). Four rates of cattle manure: Control, 2, 4, and 6 t/ha^{-1} and four rates of crop residue control, 2, 4, and 6 t/ha^{-1} replicates three times laid out in a randomized complete block design and combined factorial. Data were collected on vegetative traits and yield component and statistically analyzed and the means differences were tested for their significance using least significance difference method. The growth and yield attributes increased significantly accordingly to the rates of cattle manure and crop residue due to continuous supply of nutrient. The results of analysis of variance indicated that the effects of cattle manure were significant ($P<0.05$) for all parameters except for days to 50% emergency. Similarly, the effects of crop residue rates were significant ($P<0.05$) for all parameters except for days to 50% emergency and harvest index. The interaction effect of cattle manure by crop residue rates were significant ($P<0.05$) for all parameters except for number of cobs per plant, and cob length. The correlation analysis showed that all growth and yield parameters showed the positive and significant association to the grain yield except days to 50% emergency, days to 50% flowering, and plant height. Among the different cattle manure and crop residue used the combination of 6 t/ha cattle manure and 6 t/ha crop residue gave the maximum grain yield (7603.07 kg/ha). Hence, it can be recommended for wider use at study area while the minimum grain yield value (6055.10 kg/ha) was obtained from control plot (0, 0 t/ha). Applications of 6 t ha^{-1} cattle manure and 6 t ha^{-1} crop residue significantly improve vegetative growth and yield attributes of maize plant and therefore recommended for adoption by resource-poor farmer can adopt the use of 6 t ha^{-1} cattle manure and 6 t ha^{-1} crop residue as substitute for inorganic fertilizer, thus reduce environmental pollution posed by the disposal of the cattle waste and crop residue to ultimately improve yield and soil fertility in the study area.

Keywords: Organic; Cattle maure; Crop residue; BH-540; Maize variety

INTRODUCTION

Ethiopia is the fifth largest producer of maize (*Zea mays* L.) in Africa and smallholder farmers make up 94% of crop production with area coverage (16%) and production (26%) with about 6.5 million tons of production. Nevertheless, the average estimated yields of maize for smallholder farmers in the country are about 3.2 t ha^{-1} which is much lower than the yield recorded under demonstration plots of 5-6 t ha^{-1}. Maize is an exhaustive cereal crop having higher potential than other cereals and absorbs a large number of nutrients from the soil during

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different growth stages. However, in Ethiopia, low soil fertility and low levels of input use are some of the major constraints for crop production. Tropical smallholder farming systems including Ethiopia there are many interrelated factors, both natural and manmade, cause soil fertility decline. This decline may occur through leaching, termite, soil erosion, and lack of soil fertility restoring input, unbalanced nutrient use and crop harvesting [1].

Unless the nutrients are replenished through the use of organic or mineral fertilizers, or partially returned through crop residues, or rebuilt more comprehensively through traditional fallow systems that allow restoration of nutrients and reconstruction of soil organic matter, soil nutrient levels decline continuously. Thus the recently acquired soil inventory data revealed that the deficiencies of most nutrients such as nitrogen (86%), phosphorus (99%), potassium (7%), sulfur (92%), born (65%), zinc (53%), copper, manganese and iron are wide spread in Ethiopian soils. Therefore, to alleviate nutrient deficiencies in soils and reduction in crop yield using affordable technologies were must. These include specially the use of combinations of organic and different integrated soil fertility management. Achieving high maize yield requires an adequate and balanced supply of nutrients as declining soil fertility is a prominent constraint for maize production [2].

Ethiopia soil has a high potential for crop production yield, levels obtained under farmer's condition are usually low due to poor soil management and conservation method. The type of problem is solved through the use of either inorganic or organic fertilizer. However, the use of inorganic fertilizer by resource poor farmers is limited by its scarcity and cost and untimely availability. Under intensive agriculture, the use of inorganic fertilizer has not been helpful because it is associated with soil acidity, nutrient imbalance and reduction in crop yield. The use of organic manure and crop residues to meet the nutrient requirement of crop would be an inevitable practice since both generally improve the soil physical, chemical and biological properties along with conserving capacity of the moisture holding capacity of soil and this, resulting in enhanced crop productivity along with maintain the quality of crop produce and also reduce termite infestation [3]. Although organic manures contain plant nutrients in high qualities compared to inorganic fertilizers, the presence of growth promoting principle like enzymes and hormones, besides plant nutrient make them essential for improvement of soil fertility and productivity. Improvement in the public health and environmental condition are also the strong reason for advocating the use of organic material [4].

In the present chemical input farming system, natural (use of organic amendment viz. green mature, poultry manure, farmyard manure, crop residues and etc) can be considered to be a solution to many problems for different cropping system in different agro ecological zones. The application of inorganic fertilizer is to increase crop yield, but it becomes a chronic problem due to its cost and deterioration in soil physical, chemical and biological properties of the soil. And also it cannot guarantee long-term productivity on many soils since they are not effective in maintaining soil fertility, so that urge sustainable options [5]. Therefore, the integration of organic fertilizers like cattle manure and crop residues sources were a viable option in improving maize yields without degrading soil fertility status and reduce infestation of termite. Moreover, very little information is available on the effects of abandoning manure application and crop residues on crop productivity and soil quality. Therefore, keeping the above points in view, this study was undertaken to determine the influence of cattle manure and crop residues on yield and yield components of maize and soil fertility as well as reduce termite infestation and to determine the optimum rate of cattle manure and crop residues for maize in Western Wollega particularly in the Guto Gidda districts, Ethiopia [6].

MATERIALS AND METHODS

Description of experimental site

The study was conducted at Guto Gidda district, Western Ethiopia in 2020 main cropping season under supplementary irrigation conditions. The site is located at 8°11'52 and 10° 94'44 north latitude and 36° 97'51 and 37° 11'52 East longitude and at the altitude of 1500-1700 masl above sea level, with a prevalence of lowlands [7]. The area is located at the distance of about 40 km from Nekemte town and 365 from the Addis Ababa in the western direction. The soil texture of the area was loamy soil (42.8%), sandy soil (23.09%) clay loamy (16.33%) and clay soil (8.08%) and partially acidic soil. The area receives annual rain fall of 1200 mm-2400 mm from May to September. The maximum and minimum average annual temperatures are 31°C-16°C. The farming system of the local society used mixed farming system that involves animal husbandry and crop production (unpublished data from Guto Gidda agriculture Bureau, 2009) [8].

Description of experimental materials

Maize varieties BH-540 released by Bako agricultural research center was used as experimental material and largely grown in the area.

Treatments and experimental design

The treatment consists of factorial combination of four cattle manure (0, 2, 4 and 6 t/ha) and four crop residues/maize Stover (0, 2, 4 and 6 t/ha) arranged in Randomized Complete Block Design (RCBD) in 4 × 4 factorial arrangements with three replications. The space between plot and block was 0.5 m and 1 m respectively [9]. The gross plot consists of 4 rows, each 3 m width and 4 m long. The net plots were the middle 2 rows; the 2 outer rows of each plot were used as border rows. At planting application of both cattle manure and crop residue was buried under the soil surface, in alternate rows in the furrow. The spacing used for maize was 75 cm between rows and 25 cm between plants. The gross plot size was 3 m × 4 m (12 m^2) (width by length). Recommended rates of inorganic fertilizer DAP 100 kg/ha and Urea 200 kg/ha was applied at planting and at active growth stage of maize plant, respectively. Land preparation and other agronomic management practices were taken according to the recommendation and farmers practice [10].

Irrigation management

For the 1st month field was shallow irrigated at 7 interval days, while after a month till to tasseling and silking irrigation 10 to 12 days interval applied deeply by furrow system. And at critical time at tasseling and silking stage field was irrigated by 4 days interval to initiate flowering and silking. Most of the time irrigation has been done after noon to avoid loses of water from the field by evaporation [11].

Data collection and measurements

Soil parameters collected: Prior to sowing, soil samples were taken from sixteen representative points within the experimental area at 0 cm-20 cm depth using zigzag line in the experimental field to make a composite sample for analysis of physical and chemical properties of soil. Soil samples were collected from the experimental site at a depth of 0 cm-20 cm since maize crop roots could grow down deep to 20 cm of the top soil. Similarly, soil samples were taken from each plot after harvesting and plots those received equal fertilizer levels were composited together in to sixteen samples [12]. Soil analysis for specific parameters (texture, pH, organic carbon, organic matter, phosphorus availability, total nitrogen and potassium availability) was carried out at Nekemte soil research center as follows:

- **The texture of top soil:** (0-20 cm) was determined by modified bouyoucos method as described.
- **Total nitrogen:** This was determined using Kjeldahl method, 20 g of 2 mm sieved soils was treated with 0.32% excess alkaline KMnO and distilled water in the presence of 2.5% NaOH (extraction).
- **Soil reaction (pH):** PH of experimental site was determined with a pH meter on 1 soil: 2.5 distilled water, after the suspension was stirred using an automatic stirrer for 30 minutes Jackson.
- **Organic Carbon (OC):** Organic carbon of the site was determined by the wet digestion procedure.
- **The Organic Matter (OM):** Calculated by multiplying organic carbon content with the factor of 1.72. Organic Matter (OM)=O.C% × 1.72
- **Available phosphorous:** It was determined on a five gram soil/ sample following the procedure of Olsen et al. using the NaHCO extracting solution.
- **Available potassium:** Soil available potassium was extracted with neutral normal ammonium acetate and the content was estimated as per the procedure by using flame photometer and was expressed ppm of K_2O [13].

Agronomic parameters collected

Phenological parameters:

Days to emergence: The number of days from sowing to when 50% of the seeds sown emerged.

Days to 50% anthesis: The number of days from sowing to when 50% of the plants in the plot gave tassels.

Days to 90% maturity: The number of days from sowing to when 90% of the plant in the plot reached physiological maturity which is indicated by the formation of black layer at the base of ear kernels [14].

Growth parameters:

Plant height (cm): The height of a plant from the ground to the tip for five randomly selected plants in the plot.

Leaf area index: Leaf area at 50% silking was determined by multiplying leaf length and maximum breadth and adjusted by a correction factor of 0.75 (*i.e.* 0.75 × leaf length × maximum breadth) as suggested by. Leaf area index was calculated by dividing leaf area per sample ground area.

The leaf area index was calculated by using the formula:

$$\frac{\text{Number of leaf} \times \text{leaf length} \times \text{leaf width} \times 0.75}{0.75 \times 0.25}$$

Number of cobs per plant: Recorded as average count of five randomly taken plants in the central net plot area.

Cob length: It was measured from the point where the cob was attached to the stem to the tip of the cob.

Number of kernels per cob: Computed as the average number of kernels of five randomly taken cobs from the central net plot area.

Thousand kernels weight: It was determined from 1000 randomly taken seeds from each plot

Above ground biomass yield: It was recorded after harvesting plants from the net plot area at physiological maturity and weighing after sun drying. The biomass yield was calculated as for grain yield.

Grain yield: Plants from the net plot area were harvested and grain weight obtained. Grain yield was calculated per hectare.

Harvest index: Is the weight of grain divided by the total weight of above ground biomass (straw+grain) of each plot expressed as %, and calculated by using the following formula:

$$HI\ (\%) = \frac{grain\ yield\ (\frac{kg}{ha})}{biological\ yield\ (\frac{kg}{ha})}\ x\ 100$$

Data analysis

Analyses of variances for the data recorded were conducted using the SAS procedure. Least Significant Difference (LSD) test at 5% probability was used for mean separation. Pearson's correlation coefficients (r) between growth and yield parameters were determined [15].

RESULTS AND DISCUSSION

Soil analysis

Physico-chemical properties of soil before sowing: The results of laboratory analysis for selected physical and chemical properties of the soil before planting were presented. Accordingly, the soil was clay loam in texture and slightly acidic in reaction, with a pH of 5.72. Maize is cultivated in a wide range of soils but well drained, loose, fertile and sandy loam soils that have a pH value between 5.4 and 6.75 are optimum. The acidic nature of the soil could probably be due to the acidic nature of the parent materials and somehow extensive weathering of the soils and leaching. Furthermore, the experimental soil had low organic carbon, organic matter, total nitrogen, available phosphorus and available potassium. Categorized pH values as follows: >8.5=very high, 7.0-8.5=high, 5.5-7.0=medium and <5.5=low. Categorized organic carbon contents of <0.65% as very low, 0.65%-1.45% as low and (1.46%-2.50%) as medium. According to rating, organic matter content of soil is very low (<1%), low (1.0 to 2.5), medium (2.6 to 4.2), high (4.3 to 6), and very high (>6). Total Nitrogen (TN%) is rated as very low (<0.1), low (0.1 to 0.15), medium (0.15 to 0.25) and high (>0.25). According to rating, P (ppm) content is:(<3) very low, (4 to 7) low, (8 to 11) medium, (>11) high (Table 1).

Table 1: Soil physical and chemical properties of the experimental site before sowing.

Soil samples	Soil texture			Soil texture class	PH (H_2O)	OC (%)	OM (%)	TN (%)	AP (ppm)	AK (ppm)
	% Sand	% Silt	% Clay							
Before sowing	44	18	38	Clay loam	5.72	1.37	2.35	0.12	7.29	72

Note: OC-Organic Carbon; OM-Organic Matter; TN-Total Nitrogen; AP-Available Phosphorous; AK-Available Potassium

Physico-chemical properties of soil after harvesting

The results of laboratory analysis for selected physical and chemical properties of the soil of the experimental site after harvesting are presented. The results showed that, the texture of soil was not affected by application of organic fertilizer. Soil texture is the inherent property of the soil, which is sufficiently permanent and is often used to characterize the soil physical make up. The higher dose of organic fertilizers decreased soil pH as compared to without fertilization. The numerically maximum value of soil pH (6.55) was recorded in 6 t/ha cattle manure and 6 t/ha crop residue (control), followed by 6 t/ha cattle manure and 4 t/ha crop residue (6.45), while minimum (5.60) in 2 t/ha cattle manure, 0 t/ha crop residue. There was gradual increase in the organic carbon content in soil in higher levels of cattle manure and crop residue, where as it depleted with without fertilization (control) or low levels of fertilization.

The maximum soil organic carbon content (4.48%) was recorded from application of higher dose of organic fertilizer (t/ha) while, the minimum organic carbon content (1.07%) was recorded for control. The maximum soil organic matter (7.71%) was recorded from the higher fertilizer level, while the minimum soil organic matter (1.84%) was resulted in control. The soil organic matter was consistently low in plots with zero application of fertilizer. This can be attributed to the absence of fertilizer which would have enhanced the decomposition of organic matter in the soil. According to Plaster organic matter content of the soil can be maintained through incorporation of crop residues, mulching, and addition of organic and inorganic fertilizers.

The total nitrogen content of soil was comparatively lower for without fertilization as compared to higher levels of organic fertilizers and enhanced the total nitrogen content in soil. The maximum total nitrogen content of soil was recorded (0.38%) under higher dose of organic fertilizers, while minimum total nitrogen content was recorded (0.1%) in control. The total nitrogen status of the soil increased with increased application of organic fertilizer.

The increase in N content of the soil observed with addition of organic fertilizer can be due to release of applied of N which further enhanced microbial activities as a result of increased concentration of nutrients. The depletion in total N observed in the control plots may be attributed to nutrient up take by the crop and absence application. The application of higher dose of organic fertilizers increased available phosphorus content of soil (16.35) over rest of the treatments, while minimum available phosphorus content of soil (7.68) in control. The maximum available potassium content of soil was recorded (79.85 ppm) under the higher dose of organic fertilizer 6 t/ha cattle manure and 6 t/ha crop residue, while minimum available potassium content was recorded from control (Table 2).

Table 2: Soil physical and chemical properties after harvest.

Sample from plots with t/ha rates of cattle manure and crop residue	Soil texture			Soil texture class	PH (H_2O)	OC (%)	OM (%)	TN (%)	AP (ppm)	AK (ppm)
Treatments (t/ha)	% Sand	% Silt	% Clay							
Control	41	16	37	Clay loam	5.77	1.07	1.84	0.1	7.68	59
0CM@2CR	42	18	38	Clay loam	5.75	2.01	3.41	0.17	8.32	66
0CM@4CR	43	16	37	Clay loam	5.73	2.13	3.67	0.18	8.13	69
0CM@6CR	41	18	39	Clay loam	5.73	2.65	4.48	0.22	10.2	71.5
2CM@0CR	41	20	39	Clay loam	5.6	3.15	5.43	0.27	11.5	72.5
2CM@2CR	43	18	39	Clay loam	5.65	3.45	5.93	0.31	12.25	74
2CM@4CR	42	18	38	Clay loam	5.75	3.35	5.76	0.32	12.45	75
2CM@6CR	43	17	39	Clay loam	5.78	3.44	5.92	0.35	12.55	76.54
4CM@0CR	43	18	38	Clay loam	5.72	3.25	5.59	0.28	13.24	75.25
4CM@2CR	42	20	39	Clay loam	5.75	3.52	6.05	0.29	13.65	77.42
4CM@4CR	43	18	39	Clay loam	5.68	3.55	6.12	0.33	14.4	78
4CM@6CR	43	18	39	Clay loam	5.85	3.58	6.16	0.34	14.54	78.65
6CM@0CR	42	17	37	Clay loam	5.87	4.25	7.31	0.31	15.2	78.45
6CM@2CR	43	18	39	Clay loam	6.25	4.35	7.48	0.36	16.32	79
6CM@4CR	43	20	39	Clay loam	6.45	4.45	7.65	0.37	16.33	79.78
6CM@6CR	44	18	39	Clay loam	6.55	4.48	7.71	0.38	16.35	79.85

Note: CM-Cattle Manure; CR-Crop Residue; OC-Organic Carbon; OM-Organic Matter; TN-Total Nitrogen; AP-Available Phosphorous; AK-Available Potassium

Analysis of variance

The results of analysis of variance for different parameters are presented. The results indicated that the interaction effect of cattle manure and crop residue were significant ($P<0.05$) for all parameters except for Number cobs per plant, and cob length. Similarly, the effects of cattle manure rates were significant ($P<0.05$) for all parameters. Also effect of crop residue rates were significant ($P<0.05$) for all parameters except for harvest index. Therefore, for those parameters with non-significant interaction effects, the main effects (cattle manure and crop residue) are more important and the results were presented accordingly (Table 3).

Table 3: Mean square values for different agronomic traits affected by cattle manure, crop residue and their interaction of maize BH-540 variety.

Parameters	REP (DF=2)	CM (DF=3)	CR (DF=3)	CM × CR (DF=9)	ER (DF=30)	Mean	CV (%)
Days to 50% emergence	0.02^{ns}	0.18^{ns}	0.41^{ns}	1.03^{*}	0.44	6.77	9.83
Days to 50% anthesis	18.18^{*}	12.63^{*}	15.96^{*}	7.13^{*}	3.03	67.81	2.56
Days to 90% maturity	0.89^{ns}	87.57^{***}	31.24^{*}	15.61^{*}	3.87	115.97	1.69
Plant height (cm)	48.27^{**}	5390.72^{**}	1664.72^{**}	303.22^{***}	29.62	193.16	2.82
Leaf area index	0.06^{ns}	24.17^{**}	5.55^{**}	0.56^{***}	0.03	4.7	4.17
Number of cobs per plant	0.58^{ns}	1.68^{*}	1.46^{*}	0.26ns	0.51	2.1	24.16

Cob length	0.40^{ns}	34.19**	9.93**	0.19ns	0.12	16.01	2.2
Number of kernels per cob	151.95*	6740.64**	735.13**	218.68***	23.64	441.46	1.1
Thousand seed weight (g)	390.60*	17677.63***	2837.06***	429.39***	35	266.28	2.22
Biomass yield (kg/ha)	3911981.9**	126388835.6**	8206349.4**	25284927.9**	5082199	30110	7.48
Grain yield (kg/ha)	22995.38**	2514731.18***	300792.34***	39156.28***	3923.61	6688.94	0.93
Harvest index	0.00004^{ns}	0.0051**	0.0002^{ns}	0.002**	0.00047	0.22	9.65

Note: ^{ns}, *, ** and***-Indicates that non-significant, significant and highly significant at P<0.05. DF=Degrees of Freedom; REP=Replication; CM=Cattle Manure; CR=Crop Residue; CM X CR=Interaction of Cattle Manure by Crop Residue; CV=Coefficients of Variance

Main effect of cattle manure and crop residue on mean yield and yield components parameters of maize

Number of cobs per plant: There was a significant effect of Cattle Manure and crop residue rates on number of cobs per plant of maize. However, their interaction did not show a significant effect. Plants treated with 6 t/ha of cattle manure gave the maximum number of cobs per plant (2.41) but, were not significantly different from those plants under 4t/ha of cattle manure. The lowest number of cobs per plant (1.58) were produced under control, 0 t/ha of cattle manure (Table 4). These improvements in growth parameters with increase in rates of cattle manure applied agree with the findings of. Similar trends was observed for crop residue it was statistically significant at (P<0.05) on number of cobs per plant of maize. Plants treated with 6 t/ha of crop residue gave the maximum number of cobs per plant (2.26) but, were not significantly different from those plants under 4 t/ha of crop residue and 2 t/ha of crop residue. The lowest number of cobs per plant (1.57) were produced under control, 0 t/ha of crop residue, where higher rates of nutrients increased the average crop weight and volume. This might be attributed to the stimulating effect of crop residue that supplies plant with nutrients required for better yield.

Cob length: Cattle manure and crop residue rates had a significant effect on cob length of maize however; their interaction did not show significant effect. The longest cob length (17.47 cm) was recorded from 6 t/ha of cattle manure, while the shortest cob length (13.58 cm) was recorded from the control, 0 t/ha of cattle manure. Also crop residue was significantly different on cob length of maize. The longest cob length (16.83 cm) was recorded from 6t/ha of crop residue but, were not significantly different from those plants under 4 t/ha of crop residue while the shortest cob length (14.85 cm) was recorded from the control, 0 t/ha of crop residue. The shortest cob length was produced by the lower fertilizer levels, while the longest cob length was produced from the plants treated under the higher fertilizer doses. Such increase in cob length as organic fertilizer increase might be attributed to increase of cell division and elongation activities of maize flowering. These results agree with who reported that significant differences in cob length were recorded among fertilizer levels (Table 4).

Table 4: Main effect of cattle manure and crop residue on number cobs per plant and cob length of maize BH-540 variety during 2020 cropping season.

Treatment	Number cobs per plant (no)	Cob length (cm)
Cattle manure (t/ha)		
0	1.58^{b}	13.58^{d}
2	2.08^{ab}	16.32^{c}
4	2.33^{a}	16.65^{b}
6	2.41^{a}	17.47^{a}

Crop residue (t/ha)		
0	1.57[b]	14.85[c]
2	2.25[a]	15.73[b]
4	2.33[a]	16.62[a]
6	2.26[a]	16.83[a]
LSD (0.05)	0.59	0.29
CV (%)	24.16	2.2

Note: [a,b]Means followed by the same letters are not significantly different for each trait; LSD=least significance difference CV=coefficients of variance.

Interaction effect of cattle manure by crop residue on phenology, growth and yield and yield components of maize

Days to 50% emergence: The interaction effect of cattle manure by crop residue on mean values of DE was presented. Days to 50% emergence was significantly affected by the interaction of cattle manure by crop residue rates. The late time to 50% emergence was 8.25 days recorded from control, 0t/ha cattle manure with 0 t/ha crop residue, and it was statically in par with the treatment 2 t/ha of cattle manure × 0 t/ha crop residue (7.33 days). The fewest number of days to 50% emergence (6.00 days) was obtained from 0t/ha cattle manure with application 6 t/ha of crop residue and it was statistically in par with the treatment 2 t/ha cattle manure × 2 t/ha crop residue (6.00 day). The same result was reported who concluded that days to emergence of maize was significantly affected by cattle manure and crop residue.

Days to 50% flowering/anthesis: Days to 50% flowering was significantly affected by the interaction effect of cattle manure and crop residue rates. The longest time to 50% flowering was 71.33 days recorded from 6 t/ha cattle manure with 4 t/ha of crop residue. The fewest number of days to flowering (65.00 days) was obtained from 6 t/ha cattle manure with application of 0 t/ha crop residue but, were not significantly different from treatment control (65.33 days). In general, the higher fertilizer rates resulted longer days to flowering, while lower fertilizer levels respond shorter days to flowering for maize varieties of BH-540. The deficiency of major nutrients stunted the plant growth, resulting in maximum days taken to flowering, because organic fertilizer not quickly decompose in soil particle and affect a major role in the synthesis of proteins, nucleic acid, nucleotides, enzymes, alkaloids, vitamins and chlorophyll and flowering of maize (Table 5).

Table 5: Interaction effect of cattle manure by crop residue on days to 50% emergence and day's to 50% anthesis of maize BH-540 variety during 2020 cropping season.

Cattle manure (t/ha)	Days to 50 % emergence (day)				Days to 50% flowering/ anthesis (day)			
	Crop residue (t/ha)				Crop residue (t/ha)			
	0	2	4	6	0	2	4	6
0	8.25	7.00	7.00	6.00	65.33	67.00	67.33	65.66
2	7.33	6.00	6.66	7.00	66.66	66.66	69.00	69.00
4	7.00	7.00	7.00	6.33	65.66	68.33	68.66	69.00
6	7.00	7.00	6.66	6.33	65.00	67.66	71.33	69.66

LSD (0.05)	1.1	2.9
CV (%)	9.83	2.56
Mean	6.77	67.81

Note: Means followed by the same letters in the columns and rows of each trait are not significantly different at P=0.05; LSD=Least Significance Difference CV=Coefficients of Variance.

Days to 90% maturity: The results of the effects of cattle manure and crop residue rates for mean values of DM are presented. The results showed that the treatment combination of 0 t/ha cattle manure with 4 t/ha crop residue produced the lowest (111.00 days) and the highest days to 90% maturity (121.00 days) recorded from 6 t/ha cattle manure with 6 t/ha crop residue but, were not statistically significantly different from treatment combination of t/ha cattle manure with 4 t/ha crop residue as well as treatment combination of 6 t/ha cattle manure with 4 t/ha crop residue. Numbers of days to 90% maturity were significantly increased as cattle manure and crop residue increased. This might be because of vigorous and enhanced vegetative growth of plants at the expense of reproductive growth which brought about a delay in maturity.

Plant height: The analysis of variance showed statistically significant (P<0.05) different in plant height due to interaction effects. The results of the mean values for interaction of cattle manure with crop residue on plant height are presented in Table 6. The results indicated that 6t/ha cattle manure with application of 6 t/ha crop residue gave the maximum plant height (227.33 cm) and it was statistically in par with the treatments 6 t/ha cattle manure × 4 t/ha crop residue. While the shortest plant height with mean value of 164.66 cm was obtained from 4 t/ha cattle manure × 0t /ha crop residue treatment combination but, it was not significantly different from the treatment combination control (168.66 cm), 0 t/ha cattle manure with 4 t/ha crop residue (168.00 cm), 2 t/ha cattle manure with 0 t/ha crop residue (168.00) and 0 t/ha cattle manure with 2 t/ha crop residue (169.00). The steady increase in height of maize plants with increase in rate of cattle manure suggests that quantity of manure applied affects nutrients availability for uptake by plants which promoted vigorous plant growth through efficient photosynthesis (Table 6).

Table 6: Interaction effect of cattle manure by crop residue on days to 90% maturity and plant height of maize BH-540 variety during 2020 cropping season.

Cattle manure (t/ha)	Days to 90% maturity (day)				Plant height (cm)			
	Crop residue (t/ha)				Crop residue (t/ha)			
	0	2	4	6	0	2	4	6
0	114.66	113.33	111.00	112.66	168.66	169.00	168.00	178.66
2	113.00	113.00	117.33	116.00cd	168.00	187.00	184.00	189.66
4	113.00	115.33	120.66	119.00	164.66	199.33	217.66	218.00
6	115.33	119.66	120.66	121.00	205.00	218.66	227.00	227.33
LSD (0.05)	3.28				9.07			
CV (%)	1.69				2.82			
Mean	115.97				193.16			

Note: Means followed by the same letters in the columns and rows of each trait are not significantly different at P=0.05; LSD=Least Significance Difference CV=Coefficients of Variance

Leaf area index: Leaf Area Index (LAI) is a crucial growth index determining the capacity of plant to trap solar energy for photosynthesis and has marked effect on growth and yield of plant. The influence of cattle manure on leaf area remained significant under different application levels; maximum leaf area index (6.21) was recorded at treatment combination of 6 t/ha cattle manure with 6 t/ha crop residue, the minimum leaf area index (0.92) was recorded at treatment combination of 0 t/ha cattle manure with 0 t/ha crop residue (control). When fertilizer rate increases the coverage area of leaf was varying with rate of fertilizer. This increase in LAI could be attributed to enhanced production of carbohydrate, which might have resulted in increased leaf expansion. In agreement to this result, reported that combined application of organic fertilizer increases in LAI of crops compared to no fertilizer application. The higher LAI could be related to more number of leaves and higher leaf area per plant.

Number of kernels per cobs: Significant response of maize plant in terms of number of kernels per cob was recorded in Table 7. Results indicated that the application of 6 t/ha of cattle manure with 6 t/ha of crop residue produced the highest number of kernels per cob (476.86) but, were not statistically significantly different from treatment combination of 6 t/ha cattle manure with 4 t/ha crop residue (474.83), while the lowest number of grains per cob (4003.30) produced on plots with 0t/ha of cattle manure and 4 t/ha of crop residue. The increase in number of grains per cob might be due to availability of N at proper time, which is required for better growth and development of plants and improvement in moisture retention and soil structure by cattle manure. This result is similar to the findings of who concluded the significant effect of inorganic fertilizer, cattle manure and farm yard manure had on number of kernels per cob (Table 7).

Table 7: Interaction effect of cattle manure by crop residue on leaf area index and number of kernels per cob of maize BH-540 variety during 2020 cropping season.

Cattle manure (t/ha)	Leaf area index				Number of kernels per cob (no)			
	Crop residue (t/ha)				Crop residue (t/ha)			
	0	2	4	6	0	2	4	6
0	0.92	2.96	3.38	3.63	412.70	418.66	400.30	411.96
2	4.06	4.45	4.62	5.42	425.56	435.90	442.73	446.16
4	4.59	5.66	5.87	6.15	433.46	443.60	458.46	465.26
6	5.45	5.91	5.96	6.21	453.80	463.13	474.83	476.86
LSD (0.05)	0.32				8.1			
CV (%)	4.17				1.1			
Mean	4.7				441.46			

Note: Means followed by the same letters in the columns and rows of each trait are not significantly different at P=0.05; LSD=Least Significance Difference CV=Coefficients of Variance

Thousand seed weight: Thousand kernels weight is a major yield component that has an essential role in determining the potential yield of variety. Among the various parameters contributing to the economic yield of a crop, 1000 grain weight is of prime importance. It directly relates with the yield of crop. One thousand grain weight was significantly influenced by the application of cattle manure and crop residue (Table 8). Data revealed that maximum and minimum 1000 grain weight was 356.17 and 214.92 g from 6 t/ha cattle manure with 6 t/ha crop residue and 0 t/ha cattle manure with 2 t/ha of crop residue treatment combination, respectively. The maximum 1000 grain weight might be due to availability of N and other nutrients in the cattle manure, while the minimum 1000 grain weight might be attributed to deficiency of macronutrients throughout the plant life especially at the time of flowering and seed setting. Similar results were recorded by Shah et al. who reported that 1000 grain weight was significantly affected by combined application of inorganic fertilizer in combination with cattle manure.

Above ground biomass yield: Dry biomass yield is an important output as farmers are also interested in biomass yield for animal feed in addition to grain yield. The results for interaction effect of cattle manure × crop residue rate on mean of biomass yield are presented in Table 8. The results indicated that treatment combination 2 t/ha of cattle manure and 6 t/ha of crop residue gave significantly maximum total biomass 34520 kg/ha, as compared to other treatments but had no significant difference from 4 t/ha cattle manure × 0 t/ha of crop residue with a biomass yield of 34371 kg/ha. While, 0 t/ha cattle manure with 2 t/ha crop residue produced the minimum biomass yield, 23037 kg/ha but, it was not significantly different from control (0, 0) and 0 t/ha cattle manure with 4 t/ha crop residue biomass yield of 23674 and 25577 kg/ha respectively. The significant increase in above ground biomass yield also could be attributed due to the availability of macronutrients and some secondary nutrients formulated with the cattle manure and crop residue fertilizer, which could increase the vegetative consequently the biomass of yield. Similar significant increase in biomass yield was also observed for different application of organic fertilizers, which states that the increased in biomass yield attributed due to the proportional vegetative growth especially plant height (Table 8).

Table 8: Interaction effect of cattle manure by crop residue on thousand seed weight and above ground biomass yield of maize BH-540 variety during 2020 cropping season.

Cattle manure (t/ha)	Thousand seed weight (g)				Above ground biomass yield (kg/ha)			
	Crop residue (t/ha)				Crop residue (t/ha)			
	0	2	4	6	0	2	4	6
0	219.81	214.92	228.73	234.06	23674	23037	25577	30001
2	237.92	245.62	252.95	260.68	26996	32940	30965	34520
4	261.12	275.48	284.41	290.38	34371	31610	33643	33084
6	286.29	290.89	321.15	356.17	31782	31129	31802	26627
LSD (0.05)	9.86				3759.2			
CV (%)	2.22				7.48			
Mean	266.28				30109.96			

Note: Means followed by the same letters in the columns and rows of each trait are not significantly different at P=0.05; LSD=Least Significance Difference CV=Coefficients of Variance

Grain yield: The results for interaction effect of cattle manure × crop residue rate on mean of grain yield are presented in Table 9. The results indicated that 6 t/ha cattle manure with application of 6 t/ha crop residue resulted the highest grain yield, (7603.07 kg/ha), While the minimum grain yields were 6055.10 kg/ha, 6110.00 kg/ha and 6133.97 kg/ha were produced from control, 0 t/ha cattle manure with application of 2 t/ha crop residue and 0 t/ha cattle manure with application of 4 t/ha crop residue respectively. Positive and linear responses of grain yield to incremental rates of fertilizers. The higher response of grain yield to the highest organic fertilizer rates in the current study could attribute to the favorable climatic conditions. The applied NPS was able to stimulate the production of an optimal number of grains or to influence other yield components favorably, implying sub-optimal utilization efficiency of the crop.

Harvest index: The results for interaction effect of cattle manure × crop residue rate on mean of harvest index are presented in Table 9. The results indicated that the maximum harvest index (0.28) was recorded from 6 t/ha cattle manure with application of 6 t/ha crop residue and it was significantly different from the rest interactions. While 2 t/ha cattle manure with application of 2 t/ha crop residue, 4 t/ha cattle manure with application of 0 t/ha crop residue and 2 t/ha cattle manure with application of 6 t/ha crop residue resulted equal harvest index, 0.19 but not significantly different from rest treatment combinations. The highest result of harvest index was the indicator of high yield than the dry biomass. reported that harvest index increased with increasing rates of organic application and 10 t/ha cattle manure treatment gave the maximum harvest index, but found variation in harvest index among the maize varieties (Table 9).

Table 9: Interaction effect of cattle manure by crop residue on grain yield and harvest index of maize BH-540 variety during 2020 cropping season.

Cattle manure (t/ha)	Grain yield (kg/ha)				Harvest index (%)			
	Crop residue (t/ha)				Crop residue (t/ha)			
	0	2	4	6	0	2	4	6

0	6055.10	6110.00	6133.97	6165.70	0.25	0.26	0.24	0.20
2	6363.50	6521.70	6661.13	6774.90	0.23	0.19	0.21	0.19
4	6736.07	6831.57	6883.43	6993.93	0.19	0.21	0.20	0.21
6	6888.00	7056.83	7244.13	7603.07	0.21	0.22	0.23	0.28
LSD (0.05)	104.45				0.03			
CV (%)	0.93				9.65			
Mean	6688.94				0.22			

Note: Means followed by the same letters in the columns and rows of each trait are not significantly different at P=0.05; LSD=Least Significance Difference CV=Coefficients of Variance

Correlation analysis

The results of Pearson correlation analysis was are presented in Table 10. Both positive and negative associations between characters of the component crop have been observed. The results indicated that days to 50% emergency, days to 50% flowering, and plant height were non-significantly and negatively correlated to seed yield. Seed yield was strongly and positively correlated with days to 90% maturity (r=0.92**), leaf area index (r=0.41*), number of cob per plant (r=0.72***), cob length (r=0.88***), number of kernels per cob (r=0.84***), thousand seeds weight (r=0.45*), above ground biomass yield (r=0.89***), and harvest index (r=0.89***). Selassie, reported that, seed yield had a positive significant correlation with days to 90% maturity, leaf area index, number of cob per plant, cob length, number of kernels per cob, thousand seeds weight, above ground biomass yield, and harvest index. This shows that these factors were responsible for the production of seed yield of maize which means, indicated relatively better relationship with maize yield among the yield influencing characteristics. In contrast days to 50% emergency (r=0.29^{ns}), days to 50% flowering (r=0.10^{ns}), and plant height (r=-0.02^{ns}) were non-significantly correlated with seed yield, which means these factors had less effect on seed yield, so articulate towards the studies for different cattle manure and crop residue is critically important to increase production and productivity (Table 10).

Table 10: The Pearson correlation coefficients between pars of different growth yield and yield components maize BH-540 variety during 2020 cropping season.

Traits	DE	DF	DM	PH	LAI	NCPP	CL	NKPC	TSW	AGBY	GY
DF	0.03^{ns}										
DM	0.24^{ns}	0.04^{ns}									
PH	-0.19^{ns}	-0.03^{ns}	-0.08^{ns}								
LAI	0.34^{ns}	-0.25^{ns}	0.33^{ns}	0.26^{ns}							
NCPP	0.36^{ns}	0.04^{ns}	0.72***	0.02^{ns}	0.36^{ns}						
CL	0.42*	0.04^{ns}	0.87***	-0.01^{ns}	0.33^{ns}	0.80***					
NKPC	0.39^{ns}	0.03^{ns}	0.89***	-0.08^{ns}	0.39*	0.60***	0.79***				
TSW	0.30^{ns}	0.13^{ns}	0.46^{ns}	-0.14^{ns}	0.21^{ns}	0.33^{ns}	0.44^{ns}	0.50*			
AGBY	0.45*	0.05^{ns}	0.87***	-0.10^{ns}	0.46*	0.68***	0.81***	0.91***	0.52**		
GY	0.29^{ns}	0.10^{ns}	0.92**	-0.02^{ns}	0.41*	0.78***	0.88***	0.84***	0.45*	0.89***	
HI	0.35*	0.10^{ns}	0.94***	-0.11^{ns}	0.36*	0.72***	0.86***	0.81***	0.43*	0.83***	0.89***

Note: ^{ns}non-significant (P>0.05), * and *** correlation is significant at P<0.05 and P<0.001 respectively. DE=Days to 50% emergency, DF=Days to 50% flowering/anthesis, DM=Days to 90% maturity, PH=Plant height, LAI=Leaf Area Index, NCPP=Number of Cob Per Plant, CL=Cob Length, NKPC=Number of Kernels Per Cob, TSW=Thousand Seeds Weight (g), AGBY=Above Ground Biomass Yield (kg/ha), GY=Grain Yield (kg/ha) and HI=Harvest Index (%)

CONCLUSION

Maize is an important cereal crop of Ethiopia, serving as a source of food and income to the smallholder farmers. Its productivity is, however, low due to a number of soil fertility, crop and environmental factors. Inadequate soil nutrient availability, particularly of nitrogen, and use of low-yield potential cultivars are prominent factors limiting maize productivity. Recently, removal of crop residue on cultivated land and continuous cultivation causes a deficit of some secondary and micronutrients that have not been seen so far in some Ethiopian soils. The use of organic manure to meet the nutrient requirement of crop would be an inevitable practice since organic manures generally improve the soil physical, chemical and biological properties along with conserving capacity of the moisture holding capacity of soil and this, resulting in enhanced crop productivity along with maintain the quality of crop produce. Therefore, the objective of the study was to determine the appropriate cattle manure and crop residue for maximum yield of maize. The treatments contains four cattle manure (0, 2, 4 and 6 t/ha) and four crop residue (0, 2, 4 and 6 t/ha) factorially combined and arranged in RCBD replicated three time.

Data were collected for DE, DF, DM, PH, LAI, NCPP, CL, NKPC, TSW, AGBY, GY and HI. The collected data were subject to analysis of variance using GLM of SAS (Version 9.0, 2004). The results showed that cattle manure and crop residue highly significantly affected on number of cob per plant and cob length ($P<0.05$). Similarly, the interaction effect of cattle manure x crop residue was highly significant for days to 50% emergency, days to 50% flowering, days to 90% maturity, plant height, leaf area index, number of kernels per cob, thousand seed weight, above ground biomass yield, grain yield and harvest index.

Grain yield of maize was highest on the treatment combinations of 6t/ha cattle manure with 6t/ha crop residue and it can be recommended for production in the study area and similar agro ecologies. The correlation analysis shows that all growth and yield parameter shows the positive correlation to the seed yield except days to emergency, days to flowering and plant height. Based on the results of this study is generally concluded that of 6 t/ha of cattle manure and 6 t/ha of crop residue were advisable to achieve the good performance on yield and yield components of the maize production at studied area. The results suggest that, appropriate cattle manure and crop residue were the most provide conclusive recommendation under the existing climatic and edaphic conditions. The future studies should articulate towards the studies for different cattle manure and crop residue is critically important to increase production and productivity of maize crops. However, since this is based on one year experiment, further trails may be needed to substantiate the results.

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