Research Article

Evaluation of Different Composts Composition on the Yield and Yield Components of Maize (*Zea mays* L.)

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Abstract | Organic amendment like compost application can improve soil quality and enhance crop production in agricultural system. Two years field trials were carried out during 2011-12 at New Developmental Farm of the University of Agriculture, Peshawar, Pakistan. Thirteen compost treatments including control as main plot treatment and two fert-N levels (0 and 75 kg N ha^{-1}) as subplot treatments were used. Compost materials i.e. farmyard manure (FYM), cereal residue (CR) and legume residue (LR) were composted as sole or in various combinations six weeks before sowing and then were incorporated to plots at sowing both the years. All treatments including control were either supplemented with half of the recommended dose (75 kg N ha^{-1}) of Urea-N or no Urea-N. Compost, its composition, mineral N and their interactions significantly affected maize yield and yield components over two years average data. Compost application produced more maize ears m^{-2} (13%), grains ear^{-1} (28%), 1000 grains weight (14%), biological yield (56%), grain yield (65%) and harvest index (5%) over control. Among varying composition composts, higher grains ear^{-1}(274), 1000 grains weight (270.7g), biological yield (16151 kg ha^{-1}) and grain yield (4803 kg ha^{-1}) were observed for 100% FYM compost. Higher grains ear^{-1} (245), 1000 grains weight (255.3 g), biological yield (13374 kg ha^{-1}), grain yield (3949 kg ha^{-1}) and harvest index (29.5%) were recorded for added fert-N. Significantly more ears m^{-2} (8%), grains ear^{-1} (8%), 1000 grains weight (8%), biologically yield (14%), grain yield (26%) and harvest index (10%) were obtained in the following year over 1st year. Maize performance linearly increased with increase in FYM (25 to 75%). Compost application with or without fert-N, enhanced maize productivity, in a more productive and sustainable way. FYM as composting material is superior over legume and cereal residue.

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Introduction

In a developing country like Pakistan where population is increasing at alarming rate, food especially grains shortage is the top challenge for researchers. Soil and fertilizer management plays a vital role in crop production. The sustainable production is the current focus of agriculture system. Pakistani soils are mostly low in organic content and it can be replenished by organic matter and compost amendment (Sarwar, 2005). Fertilizers play a vital role in increasing crop productivity. One of the major factors in low productivity is poor soil fertility and less use of organic and mineral fertilizers. There is net depletion of nutrients due to more uptakes by the plants compared to fertilizer addition; resulting in deterioration of the soil health and affecting the efficiency of chemical fertilizers. For maintaining soil fertility N, P and K fertilizers are essentially needed (Afzal and Ahmad, 2009). The decrease in soil organic matter consequently decreases soil fertility as demonstrated by many researchers (Clapp et al., 1986; Tate, 1987). Compost application has a positive effect on the physical, chemical and structural properties of soil and on the soil-plant system (Inbar et al., 1992). Compost richness in humic substances influences the soil fertility, improving its structure by increasing the biological activity and the availability of nutrients (Ayuso et al., 1996).

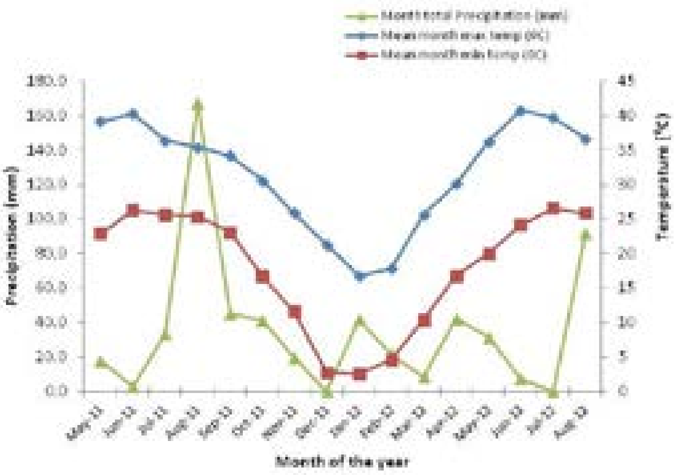

Figure 1: *Mean monthly maximum and minimum temperature (°C) and total monthly precipitation (mm) from May 2011 to Aug 2012*

Compost is a natural product which results from the controlled biological degradation of biodegradable materials, such as farm and food wastes. Compost helps in retaining soil moisture, slow release of nutrients to crops and can lead to long-term yield increases. Importantly, using compost made from recycled resources is sustainable and can increase soil organic matter and water absorbing and holding capacity. It helps to maintain and enhance soil organic matter levels, improves soil workability, supplies crop-available nutrients and trace elements and favours crops establishment and long-term yields (Giusquiani et al., 1995). Compost has been found to enhance soil properties, organic matter content and nutrient supply to plants and thus may complements mineral fertilizers in conventional agriculture and provides a useful nutrient source in organic farming (Parkinson et al., 1999). Keeping in view the current fertility status and associated problems in our country, it necessitated to work on composting of crop residues and farm yard manure in a conventional way for efficient and improved cereal productivity. The aim of the study was to evaluate the effects of the various composition composts with- out or with half of recommended N fertilizer for enhancing maize productivity.

Material and Methods

Two years field experiments were carried out during 2011-12 at Agronomy Research Farm, The University of Agriculture, Peshawar, Pakistan (34° N Latitude, 71.6° E Longitude and 359 m Altitude). The soil of the farm is silt loam, well drained, having a pH of 8.4, 400 mg kg^{-1} soil total nitrogen (NT), 2.1 mg kg^{-1} soil immobile P, 210 mg kg^{-1} soil K and 9.3 g kg^{-1} soil organic carbon. The climatic conditions of the area were warm, dry and semi-arid subtropical, having mean yearly rainfall ~ 400 mm. Though enough precipitation was observed during the growing season (Figure 1), yet at critical growth stages the crop water requirement were ensured by irrigation.

Table 1: *Details of the experimental treatments*

Main plot Treatments (Factor-A)			
Compost Treatments	Material (%)		
	FYM	CR	LR
Control	0	0	0
Cereal residue (CR†)	0	100	0
Legumes residue (LR)	0	0	100
Farmyard manure (FYM)	100	0	0
FYM +CR	75	25	0
FYM + CR	50	50	0
FYM + CR	25	75	0
FYM + LR	75	0	25
FYM + LR	50	0	50
FYM+ LR	25	0	75
FYM+ CR +LR	75	12.5	12.5
FYM+ CR + LR	50	25	25
FYM+ CR +LR	25	37.5	37.5
Subplot treatments (Factor-B)			
Inorganic Nitrogen (N)			
Without N (No-N)			
With half of recommended dose of N i.e. 75 kg N ha^{-1} (Added-N)			

†: *the ratio was managed to provide a pool of 150kg N ha^{-1} on dry weight basis;* **FYM:** *Farmyard manure;* **CR:** *Cereal residue;* **LR:** *Legume residues;* **N:** *Fertilizer nitrogen*

Thirteen compost treatments (including a control) as main plot treatments and two Urea- N levels (0 and 75 kg N ha^{-1}) as subplot treatments were used in the experiment. Randomized complete block design with split plot arrangement having 4 replications was used in the experiments. Compost materials i.e. farmyard manure (FYM), cereal residue (CR) and legume residue (LR) were applied as sole or in various ratios/combinations (Table 1). The quantity of organic material was determined on the base of its N content to have the potential of supplying 150 kg N ha^{-1}. Before calculations, samples of all three compost components (FYM, CR and LR) were analyzed for N content calorimetrically, following a Kjeldahl procedure (Bremner and Mulvaney, 1982). The composting was carried out 6 weeks before crop sowing by thoroughly mixing the composting material and burying these in pits with alternative layers of soil (conventional way) in the field. To speed up the decomposition process cereal and legume residue were chopped into small pieces and 2% solution of effective microorganisms available as BIOAAB was applied to the composting material at the time of composting. BIOAAB solution (2%) was applied at the rate of 500 L t^{-1} to the composting material uniformly. After 3 weeks, compost was turned over to speed up the decomposition process. Compost was prepared by the same procedure and applied to both crops of maize for 2 years. All these treatments including control were either supplemented with half of the recommended dose (75 kg N ha^{-1}) of Urea-N or no Urea-N. Inorganic nitrogen was supplied in split (half with sowing and remaining half at knee height). The subplot of 4 ×4.5 m size having 6 rows 75 cm apart with 4m length were used in the experiment. Phosphorus was applied to the field at the rate of 75 kg P_2O_5 ha^{-1} as single super phosphate (SSP) at sowing. All other production practices like, sowing, irrigation, weeding, hoeing and harvesting/ shelling were performed uniformly for all the treatments. Maize variety Azam was sown in 1st week of June both the years in the same field on the same plots with the same methodology and treatments combinations. During the following year the same experiment (compost and fertilizer N application) was repeated with the same procedure.

ANOVA technique was used to perceive the significance of treatment effects on the different variables under study. Combined analysis of the two years data was done using ANOVA technique and least significance difference test (Steel et al., 1997) was used to rank the statistically significant means.

Results and Discussion

Ears m^{-2}

Data averaged over two year for maize ears m^{-2} were significantly affected by year (Y), compost (C), interactions CxN, YxN and YxCxN while fertilizer (N) and interaction YxC were not significant. Control vs. other (OM) had significant effect on ears m^{-2} while rests of the pre-planned mean comparisons were not significant. Data presented in Table 2 showed that

Table 2: Ears *m^{-2} of maize as affected by compost compositions along with or without fertilizer-N over the period of 2 years (2011 and 2012)*

Treatments	No - N	N	Mean	Treatments	Means	Contrasts	Prob
Control	5.53	5.88	5.70 c	Control	5.70	Control vs. Compost	0.000
CR (100%†)	6.34	6.16	6.25 b	Compost	6.45		
LR (100%)	6.37	6.25	6.31 b	Sole	6.38	Sole vs. Mixed	0.000
FYM (100%)	6.69	6.47	6.58 ab	Mixed	6.48		
FYM+CR (75:25)	6.73	6.67	6.70 a	CR+LR	6.28	CR + LR vs. FYM	0.000
FYM+CR (50:50)	6.69	6.34	6.52 ab	FYM	6.58		
FYM+CR (25:75)	6.34	6.19	6.27 b	CR	6.25	CR vs. LR	0.026
FYM+LR (75:25)	6.60	6.41	6.51 ab	LR	6.31		
FYM+LR (50:50)	6.40	6.64	6.52ab	Two Mixed	6.48	Two Mixed vs. Three Mixed	0.935
FYM+LR (25:75)	6.46	6.24	6.35 b	Three Mixed	6.48		
FYM+CR+LR(75:12.5:12.5)	6.56	6.56	6.56ab	FYM + CR	6.49	FYM+CR vs. FYM+LR	0.022
FYM+CR+LR (50:25:25)	6.35	6.62	6.49ab	FYM + LR	6.46		
FYM+CR+LR (25:37.5:37.5)	6.46	6.31	6.38ab				
Mean	6.42	6.37					
$LSD_{(0.05)}$			0.34	Interactions		C ×N	0.000
Year-2011			6.18			Y ×C	0.000
Year-2012			6.61			Y ×N	0.000
Significance			**			Y ×C ×N	0.000

†: *the ratio was managed to provide a pool of 150 kg N ha^{-1} on dry weight basis;* **FYM:** *Farmyard manure;* **CR:** *Cereal residue;* **LR:** *Legume residues;* **C:** *Compost;* **N:** *Fertilizer nitrogen;* **Y:** *Year;* **LSD:** *least significant difference;* ****:** *highly significant* year significantly affected maize ears m^{-2} and were more (7%) during second year over previous year. Ears m^{-2} was greater (13%) for compost treated plots compared to untreated control. Compost of FYM+CR (75:25) proved superior and produced higher ears m^{-2} (6.70) over other compositions. In case of no fertilizer N, an increase in CR content of compost from 25 to 100%, resulted in a decrease in ears from 6.73 m^{-2} to 6.34 m^{-2} while in case of fertilizer N addition, this decrease was from 6.67 m^{-2} to 6.16 m^{-2} 9%. An increase in compost LR content from 25 to 100%, decreased ears m^{-2} from 6.60 to 6.37 in case of no-N while this decrease was from 6.41 to 6.25 with added-N. Looking at pre-planned mean comparisons, compost application produced more ears m^{-2} (6.45) compared to control (5.70). Maize ears m^{-2} were more (6.48) for mixed over sole (6.38) application. FYM compost gave more ears m^{-2} (6.58) than residue compost (6.28). LR compost yielded greater ears m^{-2} (6.31) compared to CR compost (6.25). FYM+CR compost proved better (6.49 ears m^{-2}) as compared to FYM+LR (6.46 ears m^{-2}).

More ears m^{-2} during year 2 might be the result of better crop growth due to more nutrients availability with more organic matter content by carry over effect of nutrients, especially nitrogen. More ears m^{-2} in compost treated plots may be the outcome of enhanced crop growth due to optimum nutrients availability and improved soil properties. Our findings are comparable to the research reports of Shah et al. (2009) who reported that combined use of urea and FYM performed best than their sole application in respect of grain yield and Ahmad et al. (2012), who documented that organic manures treatment along with synthetic fertilizers significantly enhanced agronomic efficiency over control. Application of poultry manure @ 2.50 t ha^{-1} plus mineral 200-50-25 kg NPK ha^{-1} produced more grain yield (7.74 t ha-) as a result of more ears plant^{-1}, grains ear^{-1} and 1000-grain weight. Muayayabantu et al. (2013) findings also supports our results who concluded that yield components increased under integrated soil fertility management than other treatments at the two locations of the study. Maize yield and yield component like ears plant^{-1}and cob length were maximum when the plots were fertilized with 100 kg N ha^{-1} as urea along with 100 kg N ha^{-1} as poultry manure (Nasim et al., 2012).

Table 3: *Thousand grain weight (g) of maize as affected by compost compositions along with or without fertilizer-N over the period of 2 years (2011 & 2012)*

Treatments	Mean	Treatments	Mean	Contrasts	Prob
Control	223.9 ^{i}	Control	223.9	Control vs. Compost	0.00
CR (100%†)	241.4 ^{h}	Compost	25 5.8		
LR (100%)	248.1 ^{fgh}	Sole	253.4	Sole vs. Mixed	0.04
FYM (100%)	270.7 ^{a}	Mixed	2 56.5		
FYM+CR (75:25)	260.4 ^{bcd}	CR+LR	244.8	CR + LR vs. FYM	0.00
FYM+CR (50:50)	252.6 $^{d-g}$	FYM	270.7		
FYM+CR (25:75)	246.0 ^{gh}	CR	241.4	CR vs. LR	0.03
FYM+LR (75:25)	265.8 ^{ab}	LR	248.1		
FYM+LR (50:50)	258.1 $^{b-e}$	Two Mixed	256.3	Two Mixed vs. Three Mixed	0.64
FYM+LR (25:75)	254.8 ^{def}	Three Mixed	257.0		
FYM+CR+LR (75:12.5:12.5)	263.9 ^{abc}	FYM + CR	253.0	FYM+CR vs. FYM+LR	0.00
FYM+CR+LR (50:25:25)	257.1 ^{cde}	FYM + LR	259.6		
FYM+CR+LR (25:37.5:37.5)	250.1 ^{efg}				
$LSD_{(0.05)}$	6.1				
No-N	251.2	Interactions		C ×N	0.12
Added-N	255.3			Y ×C	0.05
Significance	**			Y ×N	0.01
Year-2011	243.6			Y ×C ×N	0.33
Year-2012	263.0				
Significance	**				

†: *the ratio was managed to provide a pool of 150kg N ha^{-1} on dry weight basis;* **FYM:** *Farmyard manure;* **CR:** *Cereal residue;* **LR:** *Legume residues;* **C:** *Compost;* **N:** *Fertilizer nitrogen;* **Y:** *Year;* **LSD:** *least significant difference;* ****:** *highly significant*

The N and P content of the soil significantly increased, as did the soil organic matter, with the increased application of organic nitrogen (Mahmoud et al., 2009).

Thousand Grains Weight (g)

Thousand grains weight plays a significant role in economic yield determination. Mean maize thousand grain weight over two year was significantly affected by year (Y), compost (C) fertilizer (N) and interactions YxC and YxN while interactions CxN and YxCxN were not significant. Pre-planned mean comparisons (except 2 vs. 3 mixed) also affected thousand grain weights significantly. Table 3 presented that maize thousand grain weight was more during second year (263.0 g) than first year (243.6 g). More 1000 grain weight (255.8 g) was recorded for compost applied plots over control plots (223.9 g). FYM (100%) compost amendment resulted in highest maize thousand grain weight (270.7 g) while CR 100% compost application produced lowest (241.4 g). Added-N produced heavier grains (255.4 g) than that of no-n (251.2 g). Comparing pre-planned mean comparisons, mixed thousand grain weight was higher (256.5 g) than sole (253.4 g). Maize thousand grain weight was more (270.7 g) for FYM compost while less (244.8 g) for residues (CR+LR) compost. LR compost resulted in heavier grain production (248.1 g) than CR compost (241.4 g). Maize thousand grain weight was more for FYM+LR compost (259.6 g) than that of FYM+CR (253.0 g).

The philosophy behind this increase might be the enhanced maize crop growth due to more nutrients availability and better soil properties with application of compost. Compost composition impact was significant probably due to the different decomposition rates, chemistry and losses during decomposition. Increase in 1000 grain weight with mineral N addition might be due to better and prolonged crop growth as a result of more N availability. More 1000 grain weight during year 2 might be the consequence of enhanced and prolonged crop growth due to nutrients carry over effect. Mathur (1997) results "application of FYM improved the soil properties" supports our results. Arif et al. (2012) findings "thousand grain weight, grain yield and biological yield were significantly affected by biochar and mineral N while its effect was not significant on plants at harvest. Biochar in combination with synthetic fertilizer resulted in greater number of rows ear^{-1} and 1000- grain weight" are also comparable to our conclusion. Farm yard manure application @ 20 tons ha^{-1} along with 60 kg N ha^{-1}

Table 4: *Grains ear^{-1} of maize as affected by compost compositions along with or without fertilizer-N over the period of 2 years (2011 & 2012)*

Treatments	No-N	N	Mean	Treatments	Means	Contrasts	Prob
Control	179	204	192 ^{i}	Control	192	Control vs. Compost	0.000
CR (100%†)	223	235	229 ^{h}	Compost	245		
LR (100%)	232	241	237 ^{fg}	Sole	247	Sole vs. Mixed	0.048
FYM (100%)	258	291	274 ^{a}	Mixed	244		
FYM+CR (75:25)	239	247	243 ^{def}	CR+LR	233	CR + LR vs. FYM	0.000
FYM+CR (50:50)	229	242	236 ^{g}	FYM	274		
FYM+CR (25:75)	230	236	233 ^{gh}	CR	229	CR vs. LR	0.009
FYM+LR (75:25)	253	269	261 ^{b}	LR	237		
FYM+LR (50:50)	244	242	243 ^{def}	Two Mixed	244	Two Mixed vs. Three Mixed	0.844
FYM+LR (25:75)	241	253	247 ^{cd}	Three Mixed	244		
FYM+CR+LR (75:12.5:12.5)	247	252	250 ^{c}	FYM + CR	237	FYM+CR vs. FYM+LR	0.000
FYM+CR+LR (50:25:25)	251	236	244 ^{cde}	FYM + LR	250		
FYM+CR+LR (25:37.5:37.5)	235	242	239 ^{efg}				
Mean	235	245					
$LSD_{(0.05)}$			6	Interactions		C ×N	0.000
Year-2011			231			Y ×C	0.000
Year-2012			250			Y ×N	0.000
Significance			**			Y ×C ×N	0.005

†: *the ratio was managed to provide a pool of 150kg N ha^{-1} on dry weight basis;* **FYM:** *Farmyard manure;* **CR:** *Cereal residue;* **LR:** *Legume residues;* **C:** *Compost;* **N:** *Fertilizer nitrogen;* **Y:** *Year;* **LSD:** *least significant difference;* ****:** *highly significant* performed better than all other treatments and resulted in higher 1000-grain weight (Khan et al., 2009). The organic wastes improved the soil chemical properties and enhanced soil N content. However, the net N mineralization was affected by wastes C/N ratio and incubation period (Boechat et al., 2013).

Grains Ear^{-1}

Year (Y) as a source of variation, compost (C) and fertilizer (N) showed significant effects on maize grains ear^{-1}. Interactions and pre-planned mean comparisons except two mixed vs. three mixed, were also significant for maize grains ear^{-1}. Data shown in Table 4 indicated that maize grains ear^{-1} were 8% more during second year over 1st year. Compost treatment resulted in 28% more grains ear^{-1} over control. Highest number of grains ear^{-1} (274) was observed for 100% FYM compost while lowest (229) was noted for CR 100% compost among varying composition of compost. Considering interaction CxN, thousand grain weight decreased from 239 g to 223 g and from 247 g to 235 g respectively in case of no fertilizer N and added-N when CR content of compost was raised from 25 to 100%. With changing LR concentration of compost from 25 to 100%, maize thousand grain weight was diminished from 253 g to 232 g and 269 g to 241 g without N and added-N respectively. More (245) grains ear^{-1} were produced by added-N than no-N (235). In case of pre-planned mean comparisons, sole resulted in more grains ear^{-1} (247) than mixed (244). Maize grains ear^{-1} were more for FYM compost (274) as compared to residues compost (233). LR compost gave more (237) grains ear^{-1} as compared to CR compost (229). FYM+LR compost produced more grains ear^{-1} (250) than FYM+CR compost (237).

Increased grains ear^{-1} might be the outcome of better crop growth due to more nutrients availability and improved soil characteristics with compost treatment. Significant variation in maize grains ear^{-1} due to different composition of composts might be the result of variation in their mineralization rates, C: N and losses during decomposition. More grains ear^{-1} with fertilizer N addition may be attributed to enhanced crop growth as a result of compost and mineral N interaction. More grains ear^{-1} during year 2 may be the consequence of better crop growth due to carry over effect of organic matter and nutrients with continuous compost and mineral N addition. Our results are supported by the findings of Farhad et al. (2009), who reported that parameters like rows cob^{-1} and grains row^{-1} were significantly affected by application of poultry manure. Shah et al. (2013) also reported that humic acid levels significantly increased grains ear^{-1} and grain yield ha^{-1} with 3 kg HA ha^{-1}. Integrated use in different proportion increased grain spike^{-1} over control. Ahmad et al. (2012) reports also in line with our findings who reported that application of manures along with synthetic fertilizers significantly enhanced agronomic efficiency over control. Application of poultry manure @ 2.50 t acre^{-1} with mineral 200-150-125 kg NPK ha^{-1} produced more grain yield (7.74 t ha^{-1}) as a result of enhanced ears plant^{-1}, grains ear^{-1} and 1000-grain weight. There was higher difference in the content of nutrients in various composts (Hussain et al., 2015). Wheat residue performance was poor as compared to other residues (Kamakar et al., 2014).

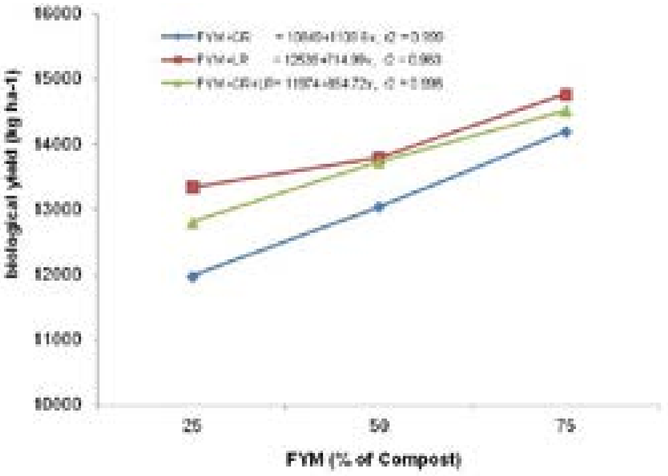

Figure 2: *Biological yield (kg ha^{-1}) of maize as affected by proportion of FYM as composting components over 2 years (2011 and 2012)*

Biological Yield (kg ha^{-1})

Mean data of maize biological yield over two year was significantly affected by year (Y), compost (C) fertilizer-N and interaction CxN while rests of the interactions were not significant. Sole vs. mixed and 2 vs. 3 mixed had no significant effect while rests of the pre-planned mean comparisons had significantly affected maize biological yield. Table 5 revealed that maize biological yield was 14% higher in the following year as compared to previous year. Application of compost produced 57% more biological yield compared to control plots. Among varying compositions, highest biological yield (16151 kg ha^{-1}) was recorded for 100% FYM compost while lowest (11390 kg ha^{-1}) for CR 100% compost. Figure 2 reveals the trend of maize biological yield with changing ratio of FYM in compost and where maize biological yield linearly increased with %FYM increase of compost.

Table 5: *Biological yield (kg ha^{-1}) of maize as affected by compost compositions along with or without fertilizer-N over the period of 2 years (2011 and 2012)*

Treatments	No-N	N	Mean	Treatments	Mean	Contrasts	Prob
Control	7725	9556	8640 ^{i}	Control	8640	Control vs. Compost	0.000
CR(100%†)	11176	11604	11390 ^{h}	Compost	13521		
LR (100%)	12450	12664	12557 ^{fg}	Sole	13366	Sole vs. Mixed	0.398
FYM (100%)	15979	16323	16151 ^{a}	Mixed	13573		
FYM+CR (75:25)	13890	14494	14192 ^{bcd}	CR+LR	11974	CR + LR vs. FYM	0.000
FYM+CR (50:50)	12967	13112	13040 ^{ef}	FYM	16151		
FYM+CR (25:75)	11720	12225	11973 ^{gh}	CR	11390	CR vs. LR	0.027
FYM+LR (75:25)	14492	15043	14768 ^{b}	LR	12557		
FYM+LR (50:50)	13662	13934	13798 $^{b-e}$	Two Mixed	13518	Two Mixed vs. Three Mixed	0.524
FYM+LR (25:75)	13189	13486	13338 ^{def}	Three Mixed	13683		
FYM+CR+LR (75:12.5:12.5)	14191	14841	14516 ^{bc}	FYM + CR	13068	FYM+CR vs. FYM+LR	0.004
FYM+CR+LR (50:25:25)	13797	13655	13726 ^{cde}	FYM + LR	13968		
FYM+CR+LR (25:37.5:37.5)	12694	12920	12807 ^{efg}				
Mean	12918	13374					
LSD$_{(0.05)}$			1029	Interactions		C ×N	0.020
Year-2011			12285			Y ×C	0.667
Year-2012			14007			Y ×N	0.175
Significance			*			Y ×C ×N	0.987

†: *the ratio was managed to provide a pool of 150kg N ha^{-1} on dry weight basis;* **FYM:** *Farmyard manure;* **CR:** *Cereal residue;* **LR:** *Legume residues;* **C:** *Compost;* **N:** *Fertilizer nitrogen;* **Y:** *Year;* **LSD:** *least significant difference;* ***:** *significant*

FYM mixing with LR resulted in maximum biological yield among all three composting categories, well fitted to linear model (r^2 = 0.96) than both its mixing with either CR (r^2 = 0.99) and CR+LR (r^2 = 0.99). In case of interaction CxN, biological yield dropped by 24% and 25% without fertilizer N and added fertilizer N respectively when CR portion of compost was changed from 25 to 100%. Referring to LR content of compost, when it was raised from 25 t0 100%; biological yield decreased by 16 and 19% for no fertilizer N and added N respectively. In case of mineral N application, added-N gave 4% more biological yield than no-N. Looking at pre-planned mean comparisons, FYM compost application resulted in production of more biological yield (16151 kg ha^{-1}) than that of residues compost (11974 kg ha^{-1}). LR compost application gave 10% higher biological yield than CR compost application. FYM+CR compost produced higher biological yield (13968 kg ha^{-1}) than that of FYM+CR (13068 kg ha^{-1}).

More biological yield may be due to more, crop growth, leaf area, plant height, ears plant^{-1}, vegetative and grain yield by greater nutrients availability with compost addition. Biological yield variation with compost composition may be attributed to difference in yield components by various fertility statuses. Enhanced biological yield with mineral N addition might be due to enhanced crop growth with more N availability. More yield in year 2 than year 1 may be attributed to enhanced crop growth due to increase in nutrients pool of the soil as a result of residual nutrients. Comparable results have been documented by Ganjali et al. (2013) and Naderi and Ghadiri (2010), who reported that application of organic composts leads to a significant increase in biological yield, and increase in application of urban waste compost and manure increased corn dry matter. Applications of maize–stover compost alone or along with urea N increased plant growth. Plant height as well as shoot yield were all significantly affected by different levels of compost both along with and without urea N (Akanbi and Togun, 2002). Application of FYM combined with EM recorded the highest yield parameters followed town refuse application and the lowest value was recorded in the treatment receiving biogas manure (Hellal et al., 2014).

Grain Yield (kg ha^{-1})

Mean maize grain yield data over two year was significantly affected by year (Y), compost (C), fertilizer (N), interactions CxN, YxC and YxN while interaction

Table 6: *Grain yield (kg ha^{-1}) of maize as affected by compost compositions along with or without fertilizer-N over the period of 2 years (2011 and 2012)*

Treatments	No-N	N	Mean	Treatments	Mean	Contrasts	Prob
Control	2125	2696	2410 ^{i}	Control	2410	Control vs. Compost	0.000
CR (100%†)	3347	3456	3402 ^{h}	Compost	3986		
LR (100%)	3602	3698	3650 ^{fgh}	Sole	3951	Sole vs. Mixed	0.513
FYM (100%)	4538	5067	4803 ^{a}	Mixed	3997		
FYM+CR (75:25)	4104	4252	4178 ^{bcd}	CR+LR	3526	CR + LR vs. FYM	0.000
FYM+CR (50:50)	3778	3858	3818 ^{efg}	FYM	4803		
FYM+CR (25:75)	3520	3548	3534 ^{gh}	CR	3402	CR vs. LR	0.099
FYM+LR (75:25)	4342	4544	4443 ^{b}	LR	3650		
FYM+LR (50:50)	3937	4134	4036 ^{cde}	Two Mixed	3990	Two Mixed vs. Three Mixed	0.783
FYM+LR (25:75)	3894	3974	3934 ^{def}	Three Mixed	4011		
FYM+CR+LR (75:12.5:12.5)	4182	4343	4263 ^{bc}	FYM + CR	3843	FYM+CR vs. FYM+LR	0.001
FYM+CR+LR (50:25:25)	4036	3987	4011 ^{cde}	FYM + LR	4138		
FYM+CR+LR (25:37.5:37.5)	3732	3786	3759 ^{efg}				
Mean	3780	3949					
LSD$_{(0.05)}$			296	Interactions		C ×N	0.000
Year-2011			3427			Y ×C	0.014
Year-2012			4302			Y ×N	0.019
Significance			**			Y ×C ×N	0.856

†: *the ratio was managed to provide a pool of 150kg N ha^{-1} on dry weight basis;* **FYM:** *Farmyard manure;* **CR:** *Cereal residue;* **LR:** *Legume residues;* **C:** *Compost;* **N:** *Fertilizer nitrogen;* **Y:** *Year;* **LSD:** *least significant difference;* ****:** *highly significant*

YxCxN was not significant. Sole vs. mixed, CR vs. LR and 2 vs. 3 mixed were not significant while rests of the pre-planned mean comparisons were significant for maize grain yield. Data presented in Table 6, indicates that grain yield was 20% more (4302 kg ha^{-1}) in second year than 1st year (3427 kg ha^{-1}). Compost treated plots produced 65% more grain yield (3986 kg ha^{-1}) compared to untreated control plots (2410 kg ha^{-1}). Among various composition composts, highest grain yield (4803 kg ha^{-1}) was produced by 100% FYM compost treated plots while lowest (3402 kg ha^{-1}) was produced by 100% CR compost amended plots. Figure 3 indicates the maize grain yield trend with changing ratio of FYM of compost. Maize grain yield increased with increase of FYM content of compost. FYM combined with LR produced highest grain yield among all three composting categories, well fitted to a linear model (r^2 = 0.89) followed by its combination with both CR+LR (r^2 = 0.99) while FYM combined with CR was at bottom (r^2 = 0.99). Inclining CR portion of compost from 25 to 100% resulted in decline of maize grain yield from 4104 kg ha^{-1} to 3347 kg ha^{-1} without fertilizer N and from 4252 kg ha^{-1} to 3456 kg ha^{-1} with added mineral N. A change of 25 to 100% of LR content of compost gave a lowering trend in grain yield from 4342 kg ha^{-1} to 3602 kg ha^{-1} for no fertilizer N and from 4544 kg ha^{-1} to 3698 kg ha^{-1}. Applied-N resulted in 4% more grain yield as compared to no-N. In case of pre-planned mean comparisons maize grain yield was higher (36%) for FYM compost as compared to residues compost. FYM+LR compost gave 8% higher grain yield over FYM+CR compost (3843 kg ha^{-1}).

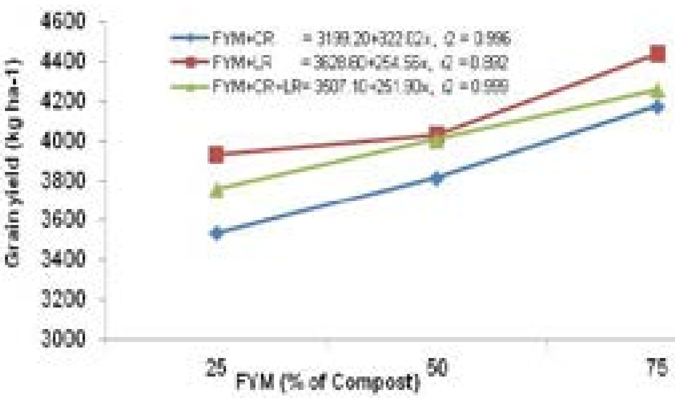

Figure 3: *Trend of grain yield (kg ha^{-1}) of maize as affected by various % of the FYM in compost over the period of 2 years (2011 and 2012)*

The increase in maize grain yield may be attributed to more crop growth, spikes m^{-2}, grains spike^{-1}, 1000 grains weight and more N uptakes in compost treated plots. Significant variation in maize grain yield with compost type may be the consequence of various spikes m^{-2}, grains $spike^{-1}$ and 1000 grain weight for different type composts. Greater grain yield may be the result of enhanced crop growth and yield components with fertilizer N addition. More grain yield during second year might be the outcomes of nutrients carry over effect and enhanced yield components with continuous compost and mineral N addition. Ouedraogo et al. (2001) and Ahmad et al. (2012) research supports our results who concluded that, sorghum yield increased 3 folds on the 10 Mg ha^{-1} compost plots and raised by 45% on the 5 Mg ha^{-1} compost amended plots, compared to control , and organic manures treatment along with synthetic fertilizers significantly enhanced agronomic efficiency over control. Application of poultry manure @ 2.50 t $acre^{-1}$ plus mineral 200-50-25 kg NPK ha^{-1} produced more grain yield (7.74 t ha-) as a result of more ears $plant^{-1}$, grains ear^{-1} and 1000-grain weight. No corn yield variations due to the type or time of manure application were noted. Application of organic composts lead to a significant increase in grain and biological yield; however it hadn't significant effect on protein content of corn (Ganjali et al., 2013). The reports of Bazzoffi et al. (1998) and Cai and Qin (2006) are in contrast to our results who reported that, maize yields were slightly, but significantly, reduced in composted plots, and wheat and maize mean yields were lower by 3.7% and 18.0% in no-N, respectively, and 1.9% and 1.5%, respectively in 1/2ON than those of full dose of NPK.

Harvest Index (%)

Maize harvest index was significantly affected by year (Y), compost (C), fertilizer (N) and their interactions for average of two year data. Except control vs. others (OM) and CR vs. LR, other pre-planned mean comparisons had no significant effect on harvest index of maize. Table 7 showed the average over two year data regarding maize harvest index. It is clear from the table that highest maize harvest index (30.7%) was recorded in the following year compared to start year (27.9%). Significantly higher harvest index was recorded for compost treated plots (29.4%) compared to control (27.9%). Considering compost composition, higher harvest index (30.0%) was observed for FYM+LR (75:25) compost application, at par with 100% CR and 100% FYM compost applied treatments while lowest (29.1%) 100% LR compost plots.

Table 7: *Harvest index (%) of maize as affected by compost compositions along with or without fertilizer-N over the period of 2 years (2011 and 2012)*

Treatments	No-N	N	Mean	Treatments	Mean	Contrasts	Prob
Control	27.6	28.2	27.9 d	Control	27.9	Control vs. Compost	0.000
CR (100%†)	29.9	29.8	29.9 ab	Compost	29.4		
LR (100%)	29.0	29.2	29.1 c	Sole	29.5	Sole vs. Mixed	0.305
FYM (100%)	28.3	31.0	29.7 abc	Mixed	29.4		
FYM+CR (75:25)	29.4	29.3	29.4 bc	CR+LR	29.5	CR + LR vs. FYM	0.419
FYM+CR (50:50)	29.1	29.4	29.2 c	FYM	29.7		
FYM+CR (25:75)	30.0	29.0	29.5 abc	CR	29.9	CR vs. LR	0.007
FYM+LR (75:25)	29.8	30.2	30.0 a	LR	29.1		
FYM+LR (50:50)	28.7	29.6	29.2 c	Two Mixed	29.5	Two Mixed vs. Three Mixed	0.211
FYM+LR (25:75)	29.5	29.5	29.5 abc	Three Mixed	29.3		
FYM+CR+LR (75:12.5:12.5)	29.4	29.2	29.3 bc	FYM + CR	29.4	FYM+CR vs. FYM+LR	0.194
FYM+CR+LR (50:25:25)	29.2	29.2	29.2 c	FYM + LR	29.6		
FYM+CR+LR (25:37.5:37.5)	29.4	29.3	29.4 bc				
Mean	29.2	29.5					
$LSD_{(0.05)}$			0.5	Interactions		C ×N	0.000
Year-2011			27.9			Y ×C	0.000
Year-2012			30.7			Y ×N	0.000
Significance			*			Y ×C ×N	0.000

†: *the ratio was managed to provide a pool of 150kg N ha^{-1} on dry weight basis;* **FYM:** *Farmyard manure;* **CR:** *Cereal residue;* **LR:** *Legume residues;* **C:** *Compost;* **N:** *Fertilizer nitrogen;* **Y:** *Year;* **LSD:** *least significant difference;* ***:** *significant*

Harvest index showed a zigzag upward trend from 29.4 to 29.9% when CR ratio of compost was increased from 25 to 100% in case of no fertilizer N while from 29.3 to 29.8 in case of added-N. Unlike CR content, LR content increase from 25 to 100% gave fall in harvest index from 29.8 to 29% and 30.2 to 29.2% for no fertilizer N and added N respectively. Added-N resulted in 1% higher harvest index than no-N. CR compost application resulted in more (29.9%) harvest index as compared to that of LR (29.1%).

Rise in harvest index with compost application, may be due to greater yields, yield components and grain N use efficiency in treated plots compare to untreated control. Significantly varying effect of compost composition on maize harvest index may be attributed to different yields, yields components and grain N uptake efficiencies for different type composts. Enhanced crop growth due to Inorganic N application may be due to improved grain yields and yield components. Higher harvest index in second year might be the outcome of higher grain yields, yield components and N use efficiencies with soil organic matter rise. Farhad et al. (2009) and Hidayatullah et al. (2013) results our similar to us who documented that, parameters like grain yield, biological yield and harvest index were significantly affected by application of PM, and grain yield showed positive correlation with enhanced plant height, tillers m^{-2}, grains $spike^{-1}$, 1000-grain weight, biological yield and harvest index. The relationship between harvest index and biological yield was inverse. Higher harvest index (32.65 %) was observed for the plot fertilized @ 175 kg N and 15 kg S ha^{-1} respectively (Ali et al., 2013). Highest values of harvest index (59.7%) were obtained from the application of the highest N rates (Getachew and Belete, 2013).

Conclusion

Experimental results revealed that compost amendment enhanced maize crop yield and yield components with or without fertilizer-N. Different composition composts were different in their effect on maize performance. Effect of compost application increased with the number of application. FYM as composting component proved superior followed by LR while CR ranked last. Initially addition of half recommended mineral N is helpful in maintaining an economical crop production. Once the sustainability of the system is gained, the need for mineral N is decreasing.

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Authors' Contribution

Dr. Mohammad Tariq Jan has supervised Mr. Zar Muhammad in his Ph.D program and this article is a portion of his Ph.D research.

References

Afzal, N., and S. Ahmad. 2009. Agricultural inputs use efficiency in Pakistan: Key issues and reform areas. Managing Natural Resources for Sustaining Future Agriculture Research briefing. NARC, PARC, Islamabad.

Ahmad, R., D. Habib, Ehsanullah and A. Rehman. 2012. Complementary effects of organic manures on the agronomic traits of spring maize. Crop Environ. 3(1-2):28-31.

Ahmad, R., S.M. Shehzad, A. Khalid, M. Arshad and M.H. Mahood. 2007. Growth and yield response of wheat (*Triticum aestivum* L.) and maize (*Zea mays* L.) to nitrogen and L-Tryptophan enriched compost. Pak. J. Bot. 39(2):541-549.

Akanbi, W.B., and A.O Togun. 2002. The influence of maize–stover compost and nitrogen fertilizer on growth, yield and nutrient uptake of amaranth. Scientia Horticulturae. 93(1):1-8. http://dx.doi.org/10.1016/S0304-4238(01)00305-3

Ali, A., Z. Iqbal, S.W. Hassan, M. Yasin, T. Khaliq and S. Ahmad. 2013. Effect of nitrogen & sulphur on phenology, growth and yield parameters of maize crop. Sci. Int. 25(2):363-366.

Arif, M., A. Ali, M. Umair, F. Munsif, K. Ali, Inamullah, M. Saleem and G. Ayoub. 2012. Effect of biochar, FYM and mineral nitrogen alone and in combination on yield and yield components of maize. Sarhad J. Agri. 28(2):191-195.

Ayuso, M., T. Hernández, C. Garcia and J.A. Pascual. 1996. Stimulation of barley growth and nutrient absorption by humic substances originating from various organic materials. Biores. Technol. 57:251-257. http://dx.doi.org/10.1016/S0960-8524(96)00064-8

Bazzoffi, P., S. Pellegrini, A. Rocchini, M. Morandi and O. Grasselli. 1998. The effect of urban refuse compost and different tractors tyres on soil physical properties, soil erosion and maize yield. Soil Till. Res. 48(4):275-286. http://dx.doi.org/10.1016/S0167-1987(98)00133-0

Boechat, C.L., J.A.G. Santos and A.M.A. Accioly. 2013. Net mineralization nitrogen and soil chemical changes with application of organic wastes with 'Fermented Bokashi Compost'. Acta Scientiarum. Agronomy Maringa. 35(2):257-264.

Bremner, J.M., and C.S. Mulvaney. 1982. Nitrogen total. Pp. 395-622. *In:* A.L. Page, Miller and D.R. Keeney, (eds). Method of soil analysis, Part II. 2nd edition. American Society of Agronomy. Madison. WI.

Cai, Z.C., and S.W. Qin. 2006. Dynamics of crop yields and soil organic carbon in a long-term fertilization experiment in the Huang-Huai-Hai Plain of China. Geoderma. 136:708-715. http://dx.doi.org/10.1016/j.geoderma.2006.05.008

Clapp, C.E., S.A. Stark, D.E. Clay and W.E. Larson. 1986. Sewage sludge organic matter and soil properties. In: Chen, Y., Avnimelech, Y. (Eds.). The Role of Organic Matter in Modern Agriculture, Martinus Nijhoff Publishers, Dordrecht, p. 88–97. http://dx.doi.org/10.1007/978-94-009-4426-8_10

Farhad, W., M.F. Saleem, M.A. Cheema and H.M. Hammad. 2009. Effect of poultry manure levels on the productivity of spring maize (*Zea mays* L.). J. Anim. Plant Sci. 19(3):122-125.

Ganjali, H.R., H.R. Mobasser, A. Esmaielzehi and A. Tavassoli. 2013. Effects of organic composts on yield and protein content of corn cultivars in Khash region. J. Novel Appl. Sci. 2(9):369-374.

Getachew, M., and K. Belete. 2013. Yield related traits and yield of maize (*Zea mays* L.) as affected by green manuring and nitrogen levels at Mizan Teferi, South-West Ethiopia. Int. J. Agron. Plant Prod. 4(7):1462-1473.

Giusquiani P.L., M. Pagliai, G. Gigliotti, D. Businelli and A. Benetti. 1995. Urban waste compost: effects on physical, chemical, and biochemical soil properties. J. Environ. Qual. 24:175-182. http://dx.doi.org/10.2134/jeq1995.241175x

Hellal, F.A., R.M. Zewainy, A.A. Khalil and A.A.M. Ragab. 2014. Effect of organic and bio-fertilizer management practices on nutrient availability and uptake by Faba bean- Maize sequence. American-Eurasian J. Sust. Agri. 8(5):35-42.

Hidayatullah, A. Junior, A. Jan and Z. Shah. 2013. Residual effect of organic nitrogen sources applied to rice on the subsequent wheat crop. Int. J. Agron. Plant Prod. 4(4):620-631.

Hussain, S.S., T. Ara, F.A. Raina, G. Gani, N. Hussain and M. Hussain. 2015. Quality evaluation of different forms of compost and their effect in comparison with inorganic fertilizers on growth and yield attributes of wheat (*Triticum aestivum* L.). J. Agric. Sci. 7(1):154-160.

Inbar, Y., Y. Hadarand Y. Chen. 1992. Characterization of humic substances formed during the composting of solid wastes from wineries. Sci. Tot. Environ. 113:35-48. http://dx.doi.org/10.1016/0048-9697(92)90015-K

Jan, M.T., P. Shah, P.A. Hollington, M.J. Khan and Q. Sohail. 2009. Agriculture Research: Design and Analysis, A Monograph. NWFP Agric. Univ. Pesh. Pak.

Kamkar, B., F. Akbari, J.A.T.D. Silva and S.A.M. Naeini. 2014. The effect of crop residues on soil nitrogen dynamics and wheat yield. Adv. Plants Agri. Res. 1(1):1-7. http://dx.doi.org/10.15406/apar.2014.01.00004

Khan, A., M.T. Jan, K.B. Marwat and M. Arif. 2009. Organic and inorganic nitrogen treatments effects on plant and yield attributes of maize in different tillage systems. Pak. J. Bot. 41(1):99-108.

Mahmoud, E., N.A.E. Kader, P. Robin, N.A. Corfini and L.A.E. Rahman. 2009. Effects of different organic and inorganic fertilizers on cucumber yield and some soil properties. World J. Agri. Sci. 5(4):408-414.

Mathur, G.M. 1997. Effect of long-term application of fertilizers and manures on soil properties and yield under cotton-wheat rotation in north-west Rajasthan. J. Indian Soc. Soil Sci. 45:288-292.

Muyayabantu, G.M., B.D. Kadiata and K.K. Nkongolo. 2013. Assessing the effects of integrated soil fertility management on biological efficiency and economic advantages of intercropped maize (*Zea mays* L.) and soybean (*Glycine max* L.) in DR Congo. Am. J. Exptal. Agri. 3(3):520-541. http://dx.doi.org/10.9734/AJEA/2013/2628

Naderi, R., and H. Ghadiri. 2010. Urban waste compost, manure and nitrogen fertilizer effects on the initial growth of corn (*Zea mays* L.). Desert. 15:159-165.

Nasim, W., A. Ahmad, T. Khaliq, A. Wajid, M.F.H. Munis, H.J. Chaudhary, M.M. Maqbool, S. Ahmad and H.M. Hammad. 2012. Effect of organic and inorganic fertilizer on maize hybrids under agro-environmental conditions of Faisalabad-Pakistan. African J. Agri. Res. 7(17):2713-2719.

Ouedraogo E., A. Mandob and N.P. Zombréc. 2001. Use of compost to improve soil properties and crop productivity under low input agricultural system in West Africa. Agric. Ecosys. Environ. 84:259–266. http://dx.doi.org/10.1016/S0167-8809(00)00246-2

Parkinson, R., M. Fuller and A. Groenhof. 1999. An evaluation of green waste compost for the production of forage maize (*Zea mays* L.). Compost Sci. Utilization. 7(1):72–80. http://dx.doi.org/10.1080/1065657X.1999.10701955

Sarwar, G. 2005. Use of compost for crop production in Pakistan. Okologie abd Umweltsicherung, 26/2005. Universitat Kassel, Fachgebiet Land schaftsokologie and Naturschutz, Witzenhausen, Germany.

Shah, S.A., W. Mohammad, S.M. Shah and M.S. Shafi. 2013. Effect of organic and chemical nitrogen fertilizers on grain yield and yield components of wheat and soil fertility. Sci. J. Agron. Plant Breed. 1(2):37-48.

Shah, S.T.H., M.S.I. Zamir, M. Waseem, A. Ali, M. Tahir and W.B. Khalid. 2009. Growth and yield response of maize (*Zea mays* L.) to organic and inorganic sources of nitrogen. Pak. J. Life Soc. Sci. 7(2):108-111.

Steel, R.G.D., and J.H. Torri. 1997. Principles and procedures of statistics: A biometrics approach, 2nd ed. McGraw-Hill, New York.

Tate, R.L. 1987. Soil Organic Matter: Biological and Ecological Effects. Wiley, New York. Pp. 98–99.