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EFFECTS OF ORGANIC MATERIALS ON DRY MATTER ACCUMULATION, YIELD AND ECONOMIC BENEFITS OF CORN

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Abstract

Field experiments were conducted using "Zhengdan 958" as the experimental material to study the effects of two different organic materials to the field on the dry matter accumulation, yield, and economic benefits of corn cultivation. Results indicate that straw and pig manure as organic materials both contribute to increasing the accumulation of dry matter and yield of corn. Comparatively, the effect of pig manure found to be more significant. At maturity, returning pig manure to the field can increase the accumulation of mature corn dry matter by 15.85%, yield by 21.93%, and economic benefits by 23.41%.

Introduction

In recent years, the continuous increase in the application of chemical fertilizers has led to significant soil degradation, nutrient imbalance, and environmental pollution issues (Cong *et al*. 2011). Organic materials contain abundant organic matter, nitrogen, phosphorus, and various trace elements, which can enhance soil fertility(Alam *et al*. 2024), promote water-fertilizer coordination, and increase crop yields (Berton *et al*. 1997). China has abundant organic material resources, with approximately 7×10^{11} kg of straw and 2.5×10^{9} kg of livestock and poultry manure produced annually (Chen *et al*. 2016). However, their utilization rate is relatively low, leading to serious environmental pollution issues, making them important agricultural non-point source pollutants (Schlegel *et al*. 2016). The use of various organic materials such as straw and livestock manure for returning to the fields can effectively alleviate ecological environmental pollution and promote the sustainable and healthy development of agriculture (Pagliari *et al*. 2018). Corn is China's largest grain crop, with a planting area exceeding 4×10^{6} hm^2, occupying an important position in ensuring national economy and food security. In recent years, many researchers have begun to explore the impact of organic material return on corn production, but the effects of different organic materials on corn have not been reported. Based on this, field experiments were conducted using "Zhengdan 958" as the experimental material to compare the effects of returning different organic materials to the fields on the accumulation of substances and yield of corn.

Materials and Methods

The experimental site is in Xi'an City, Shaanxi Province, situated in the northern temperate monsoon region. It belongs to a temperate continental semi-humid monsoon climate, with an annual average temperature of 11.2°C, an average annual precipitation of 800 mm, an average annual sunshine duration of 2,996 hrs, an average relative humidity of 73%, and an average frost-free period of 173 days.

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The corn variety employed in the experiment was "Zhengdan 958", with land preparation on June 29th, sow on July 3rd, and harvested on October 24th. The nitrogen fertilizer used in the experiment was urea (pure nitrogen 46%), the phosphorus fertilizer was calcium superphosphate (pure phosphorus 12%), and the potassium fertilizer was potassium sulfate (pure potassium 50%). The wheat straw used in the experiment contained 9.96 g/kg total nitrogen and 4.64 g/kg total phosphorus, while the pig manure used contained 16.18 g/kg organic matter, 17.50 g/kg total nitrogen, and 7.60 g/kg total phosphorus.

The experiment adopted a randomized block design, comprising three treatments, each replicated three times, resulting in a total of nine plots, all with an area of 20 square meters. The treatments included a control group (CK), Treatment 1 (full incorporation of wheat straw after shredding, 4,028.95 kg/hm^2), and Treatment 2 (pig manure, 2,293.05 kg/hm^2). Each treatment received basal applications of 90 kg/hm^2 urea, 75 kg/hm^2 calcium superphosphate, and 150 kg/hm^2 potassium sulfate, followed by two plowings after the basal fertilization and seeding. During the corn tasseling stage, furrows were opened to apply 90 kg/hm^2 urea following(Tagarakis and Ketterings 2017). The field management practices for each treatment were consistent with standard field practices (Wei *et al.* 2016).

At the corn jointing stage, tasseling stage, grain filling stage, and ripening stage, five representative plants were randomly selected from each experimental plot (Saree *et al.* 2012). These plants were subjected to desiccation at 105°C for 4 hrs, followed by drying at 60°C until a constant weight was achieved, thereby obtaining the dry matter accumulation of corn plants at each growth stage (Kenichi 2017). During the corn harvesting period, corn from each experimental plot was harvested and then threshed indoors to measure parameters such as grain number per ear and hundred-grain weight, enabling the calculation of corn yield following(Brooker *et al.* 2020).

Results and Discussion

The dry matter accumulation of corn at different growth stages under different treatments is shown in Table 1. Based on this, we can understand the variability between the dry matter accumulation of maize at different time periods.

Table 1. Dry matter accumulation in different growth stages of corn under different treatments (g/plant).

Handle	Seedling stage	Jointing stage	Big horn period	Silking	Dry matter accumulation	Mature period
CK	0.65^a	26.81^b	87.19^b	165.59^b	360.67^c	504.89^c
T1	0.63^a	27.26^b	87.79^b	177.45^{ab}	383.71^b	533.43^b
T2	0.69^a	30.66^a	93.82^a	198.02^a	420.95^a	584.92^a

Here the value is statistically significant at PL 0.05, significant at PL 0.05 level. a, b, c represent different basal fertiliser application rates.

Table 1 reveals that during the corn seedling stage, the differences in dry matter accumulation among various treatments are not significant, ranging between 0.63 to 0.69 g per plant. However, as the jointing stage approaches, significant variations in corn dry matter accumulation among different treatments become apparent, with treatment T2 exhibiting the highest accumulation (30.66 g per plant), significantly surpassing CK and T1 treatments (with no significant difference between the two). As the corn progresses to the tasseling stage, the trends in dry matter accumulation across different treatments mirror those observed during the jointing stage, with treatment T2 reaching the highest value (93.82 g per plant). At the silking stage, treatment T2 demonstrated the highest dry matter accumulation (198.02 g per plant), while the CK treatment records the lowest (165.59 g per plant), with no significant difference observed between T1 and CK treatments, nor between T1 and T2 treatments. Moving to the grain filling stage, the dry matter accumulation in corn followed a descending order across different treatments, with treatment T2 recording the highest accumulation (420.95 g per plant), followed by T1 treatment (383.71 g per plant), and CK treatment (360.67 g per plant). Similarly, during the maturity stage, the trend in dry matter accumulation among different treatments closely resembles that observed during the grain filling stage, with treatments T2 and T1 showing an increase of 15.85 and 5.65%, respectively, compared to the CK treatment.

The impact of different organic materials on corn yield and yield attribute is shown in Table 2.

Table 2. Corn yield and yield composition indicators under different treatments.

Handle	Number of rows/year	Number of grains/row	Number of grains/spike	Seed yield/%	Production/ (kg·hm^{-2})
CK	15.67^{ab}	35.78^{b}	543.00^{b}	78.11^{b}	7992.73^{c}
T1	16.59^{a}	38.91^{a}	534.45^{b}	78.69^{ab}	8792.82^{b}
T2	15.44^{a}	38.91^{a}	562.99^{a}	79.34^{a}	9745.49^{a}

Here the value is statistically significant at PL 0.05, significant at PL 0.05 level. a, b, c represent different basal fertiliser application rates.

From Table 2, it is evident that among the various treatments, the number of rows per corn cob highest in treatment T1, reaching 16.59 rows, while it is lowest in treatment T2, with only 15.44 rows. The difference in row numbers between treatments T1 and CK is not significant, nor it significant between treatments T1 and T2. The differences in row numbers per corn cob between the two organic material returning treatments are also not significant, both standing at 38.91 rows, but notably higher than the 35.78 rows in the CK treatment. Treatment T2 exhibited the highest number of grains per corn cob, reaching 562.99 grains, significantly surpassing both CK and T1 treatments (with no significant difference between them, ranging between 534.45 to 543.00 grains). The differences in deed yield among different treatments are not significant, ranging from 78.11 to 79.34%. Upon analyzing corn yields, it was observed that corn yield across the three treatments ranked from highest to lowest as T2, T1, and CK treatments, with treatments T2 and T1 increasing yield by 21.93 and 10.01%, respectively, compared to the CK treatment.

The cost and economic benefits of corn cultivation under different treatments are shown in Table 3.

Table 3. Planting costs and economic benefits of corn under different treatments.

Handle	Production/ (kg·hm^{-2})	Income/ (yuan·hm^{-2})	Production material cost/(yuan·hm^{-2})	Mechanical input cost/ (yuan·hm^{-2})	Labor costs	Mature period
CK	7992.73	19981.83	3000	2400	2700	11881.83
T1	8792.82	21982.05	3000	3150	2700	13132.05
T2	9745.49	24363.73	4500	2400	2800	14663.73

From Table 3, it is discernible that the economic benefits of corn cultivation vary across treatments, with the order from highest to lowest being T2, T1, and CK treatments. Specifically, the economic benefits in treatments T2 and T1 surpass those in the CK treatment by 23.41% and 10.52%, respectively.

Soil fertility stands as a pivotal determinant of agricultural productivity, bestowing upon crops an array of vital nutrients necessary for their growth and development, thereby directly influencing their prosperity. The incorporation of organic materials into the soil stands as a cornerstone of eco-friendly agricultural practices, elevating soil nutrient levels and enhancing its physicochemical properties, thereby bearing a positive significance on crop yields. This study reveals that in comparison to sole chemical fertilization, the application of pig manure and straw, both organic materials, facilitates the accumulation of corn biomass and augments corn yield during maturation, a finding consistent with research by Shaoyun *et al.* (2017), and Wang Qiujie *et al*. (2018). This enhancement primarily arises from the capacity of straw and pig manure to augment the organic carbon and total nitrogen content within the soil's surface layer, thereby maintaining a high level of soil organic carbon and total nitrogen, thereby enriching soil fertility. The combined application of straw and pig manure with inorganic fertilizers synchronizes nitrogen release in the soil with crop growth and nutrient uptake, thereby mitigating nitrogen loss caused by sluggish crop growth and concurrently enhancing nitrogen fertilizer utilization efficiency.

This study indicates that the incorporation of straw and pig manure, both organic materials, contributes to enhancing the accumulation of corn biomass and yield. Comparatively, the augmentative effect of pig manure is more pronounced. During maturation, the application of pig manure boosts corn biomass accumulation by 15.85%, yield by 21.93% and economic benefits by 23.41%.

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