Straw mulching effects on agro-ecosystem and yield components of rapeseed (*B.napus*) under no-tillage condition

ZHOU Kejin[1,2], XING Jun[3], LIU Lei[3], LU Wei[2], SONG Guoliang[2]

[1]*Branch Center of National Oilseed Improvement Center, Hunan Agricultural University, Changsha, 410128, China*
Email: zhoukejin@163.com
[2]*College of Agronomy, Anhui Agricultural University, Hefei, 230036, China*
[3]*Anhui Agricultural Technology Extension Station, Hefei, 230001, China*

Abstract

Field experiment was employed with completely random block design to study the effects of agro-ecosystem and rapeseed (*Brassica napus* L.) physiological effect and yield effect of different cultivation pattern treatments of no-tillage with straw mulching, no-tillage, and rotary tillage. The results showed that no-tillage with straw mulching could increase surface soil moisture content and temperature and improve soil physical and chemical properties and soil fertility, raise soil nutrient content including organic matter and available P and K content, and control field weeds and diseases occurrence. So, the rapeseed yield in treatment of no-tillage with straw mulching was the highest, reaching 2677.5kg/hm^2, and no-tillage treatment was the lowest, only 2349.0kg/hm^2. The rapeseed yield in the treatments of no-tillage with straw mulching, and rotary tillage were 13.9% and 7.2% more than that of no-tillage separately, and the rapeseed yield in treatment of no-tillage with straw mulching was significantly higher than that of no-tillage. The increase of rapeseed yield in straw mulching treatment was due to its effects on the increase of pods per plant and seeds per pod, not on the seed weight.

Key words: straw mulching, no-tillage, soil physical and chemical properties, agro-ecosystem, *Brassia napus*

Introduction

Returning straw is more beneficial to the cropping system than burning or removal (Kumar et al., 2002). The immobilization of initial soil inorganic N can be increased by straw amendment while net mineralization of soil organic N was not reduced (Bremer et al., 1997). Soil fertility can be improved by continuous application of rice straw and short-term effects can be investigated by combining N fertilizer and straw application (Takahashi et al., 2003).

No-tillage with straw mulching can not only improve soil properties and water use efficiency and defend soil eroded and increase grain yield, but can also improve the sustainable development of agriculture in this region in the long-term[1-4]. No-tillage would not only make soil natural structure and interstice for order distribution, but also maintain its stability in time and space. Thus, it in propitious to crops growth[7]. It is no significant difference between the contents of the effective nutrient of no-tillage soil and conventional cultivation, and the content of effective potassium still drops[8-9]. It is helpful for improving soil fertility with the cooperation of continuous no-tillage and rotation[5]. The technology of no/little tillage mainly was applied in north district including wheat, corn and bean etc. in our country at present, but it is not enough to researching and applying this technology in south land crops for instance Rapeseed (*Brassia napus*). The objective of this paper was to determine the ecology effects of covered straw on soil and the effect of yield on rapeseed.

Materials and methods

Soil samples were taken from a year field experiment at the experimental station in Anhui Agricultural University in Hefei city (32.5°N, 118.3°E) in August 2004. The forward crop is rice in this field. The soil taxonomy unit is belonged to clay pan yellow-cinnamon. Soil organic matter is 0.85 percent and pH is 6.65, available N is 22.3 mg/kg, available P is 24.3 mg/kg, quick-acting K is 46.9 mg/kg, available S is 31.0 mg/kg, available B is 3.3 mg/kg, Cu is 5.9 mg/kg,Zn is 5.2 mg/kg (according to the method of ASI from America).

The treatments selected are described in No-tillage with straw mulching, No-tillage uncovered and conventional-tillage uncovered. The plot experiment has three repetitions, randomized block arrangement and each plot area is 40 m^2. The amount of straw covered is 2700 kg/hm^2, its content of nutrient is N 0.98% and P_2O_5 0.44% and K_2O 2.26%. The fertilizers of N, P_2O_5, K_2O and borax are 225, 112.5, 75 and 7.5 kg/hm^2 respectively, and 50% of N is used for basic fertilizer and others are used basic fertilizers. The variety for experiment is Huawanyou No.2 that is sowed in Oct 5 and sowing quantity is 2.25kg/hm^2 and the planting mode is direct sowing.

The contents of total and available N, P_2O_5, K_2O are mensurated according to general methods. The contents of Soil organic matter is mensurated according to $FeC1_3$ — $K_2Cr_2O_7$ volumetric analysis. The temperature of soil is mensurated in time 8 am, 2 pm, and 8 pm in a day[12].

Results

The effects of remaining soil moisture with No-tillage with straw mulching

According to the inquiry in Nov 15, 2004, the moisture content of 0-5cm soil layer of no-tillage with straw mulching treatment is higher by 11.3% than that of no-tillage uncovered treatment, and is higher by 19.7% than conventional-tillage uncovered treatment. The difference of the moisture content of 5-10cm soil layer is small among three treatments. The change trend of water content between straw mulching treatment and uncovered treatment is contrary along with soil layer changes (Table 1). Therefore, the effect of straw mulching on soil moisture remained is very well in this experiment.

Table 1 The soil moisture content of covered straw and uncovered straw culture in rapeseed field (%)

Soil layers	Cultivation mode		
	no-tillage with straw mulching	no-tillage uncovered	conventional-tillage uncovered
0-5cm	28.5	25.6	23.8
5-10cm	27.8	26.5	25.9

The effects of increasing soil temperature and resisting freezing injury with straw mulching

Straw mulching can reduce the change of air temperature and alter the microclimate in the covered district. The temperature of soil surface and 5cm soil layer will go up in straw mulching treatment during winter stage, which is improved by 0.5-2.5°C compared with uncovered treatments and the difference in temperature reached 0.8-1.7°C. But the effect of remaining temperature is worst in the treatment of conventional-tillage uncovered. In addition, straw mulching can reduce the change of soil temperature. In the covered district, the highest soil temperature always is lower than comparison when soil temperature goes up in a day, and the lowest temperature is higher when soil temperature goes down in a night. The day-night difference of mean temperature in soil surface is 6.7°C in straw mulching plots and 12.9°C in uncovered plots, the difference of both is 6.2°C that is small of soil temperature day-night difference. It has heat preservation effect when temperature decreased.

Table 2 The inquiry of freezing injury occurrence level in wintering period of Rape

Cultivation mode	Freezing injury level				Rate of freezing injury(%)	Index of freezing injury(%)
	zero	first	second	third		
No-tillage with straw mulching	16	15	4	0	54.3	32.9
No-tillage uncovered	13	17	5	0	62.9	38.6
Conventional-tillage uncovered	14	18	3	0	60.0	34.3

Note: The table data is the average of two results in different inquiry date(Jan 10 and 17, 2005).

From the inquiry of the result of seedling freezing injury during wintering stage(table 2), the rate of seedling freezing injury is highest in the treatment of no-tillage uncovered rape, that is 62.9%; the second is the treatment of conventional-tillage uncovered, it is 60%; the lowest is the treatment of no-tillage with straw mulching, it is 54.3%. the index of freezing injury of 3 treatments is 38.6%. 34.3%. 32.9% respectively. the straw mulching has a role in safety living through winter and improving the ability of resistant freezing in rape seedling.

The effect of straw mulching on controlling field weeds

The quantity of weeds lessens greatly and the growth of weeds is suffocated with straw mulching plots in seedling stage and other growing stages. the weeds density of no-tillage with straw mulching treatment is less 62.4% than that of no-tillage uncovered treatment, but has a small increase by 7.8% than the treatment of conventional-tillage uncovered sowing during wintering stage, and thereafter, the trend keeps to accords like before (table 3).

Table 3 The inquiry of the weeds densities in different treatments (plants/m^2)

inquiry date	December 10, 2004	March 15, 2005	May 5, 2005
No-tillage with straw mulching	41.0	75.0	38.0
No-tillage uncovered	109.0	131.0	96.0
Conventional-tillage uncovered	38.0	67.0	33.0

The soil physical and chemical properties improved by straw mulching

The soil can be avoided to rap by rainfall and it can decrease water evaporation from soil surface layer in the case of straw mulching. The soil organic matter will increase and the activity of edaphons also will improve, so that cultivation layer changes to loosen slightly after straw mulching rotted. From Table 4, the soil organic matter and Available N or P or K all increased to some extent, but the Ratio of weight and volume in soil decreased. It has a part role of fating soil power and improving soil structure.

The contents of soil available N, available P and available K had increased after covering straw mulching that was higher than that of uncovering straw mulching. But the soil organic matter content was not different obviously between covering and uncovering straw mulching treatments. The soil ratio of weight and volume was also basic identical between the treatment of straw mulching and the treatment of conventional-tillage uncovered. The soil total porosity of straw mulching treatment was

higher than no-tillage uncovered treatment (Table 5)

Table 4 The soil physical and chemical properties before or after experiment of straw mulching

Item	Organic matter(%)	Total N(%)	Available N(mg/L)	Available P(mg/L)	Available K (mg/L)	Ratio of weight and volume in 0-10cm soil level(g/m^3)
Before Exp.	0.85	0.10	22.3	24.3	85.2	1.34
After Exp.	0.87	0.11	23.8	26.7	87.3	1.30

Table 5 The difference of soil physical and chemical properties between straw mulching and uncovered straw treatments

Cultivation pattern	Physical property(0－10cm)		Chemical property(0－20cm)			
	Ratio of weight and volume(g/cm^3)	Total porosity (%)	Available N (mg/L)	Available P (mg/L)	Available K (mg/L)	Organic matter(%)
No-tillage with straw mulching	1.30	51.76	23.8	26.7	87.3	0.87
No-tillage uncovered	1.35	50.13	22.0	23.9	84.1	0.86
Conventional-tillage uncovered	1.31	51.24	21.8	22.7	83.8	0.85

Effect of straw mulching on the resistant diseases in Rapeseed

The occurrence rates of Virus disease and *sclerotinia sclerotiorum* are different between the treatments of straw mulching and uncovering. Virus disease occurrence rate sizes that no-tillage uncovered treatment is highest and the second is conventional-tillage uncovered treatment and the lowest is no-tillage with straw mulching treatment. And this diseased index is consistent with the rate of disease. But the sclerotinia sclerotiorum occurrence rate is not identical with Virus disease among different treatments, and they size that the rate of conventional-tillage uncovered treatment is highest and the lowest is no-tillage with straw mulching treatment (Table 6).

Table 6 The inquiry of diseases occurrence of rapeseed plants in different treatments

Cultivation mode	Virus disease		*sclerotinia sclerotiorum*	
	Rate of diseased plant (%)	Diseasedness index(%)	Rate of diseased plant (%)	Diseasedness index(%)
No-tillage with straw mulching	4.6	2.7	21.5	10.4
No-tillage uncovered	5.8	3.1	19.5	13.3
Conventional-tillage uncovered	5.2	2.9	25.3	14.7

Effect of straw mulching on growth and development

There is more rapid sprout and neat seedling and it's lower-hypocotyl elongates in the seedling stage in the treatment of straw mulching. Thus, the seedling height of straw mulching treatment is higher than uncovering treatments in seedling stage. The growth course after straw mulching is more rapid about 3-5d than that of uncovering treatments. According to the survey of 20, Dec., seedling height and No of leaves and root stem diameter and max leaf area of straw mulching treatment are markedly higher than no-tillage uncovering treatment (Table 7). As a result, straw mulching can accelerate the growth and in favor of forming strong seedling and live through the winter.

The mature stage is earlier and No of the branches is larger in straw mulching treatment than no-tillage uncovering treatment. It's branches of first and second increased 41.8% and 153.2% separately than that of no-tillage uncovering treatment, and the difference is very notable.

Table 7 The index of main characters of different treatments in seedling stage in Rape

Cultivation mode	Height (cm)	No. of green leaves	Root stem diameter (cm)	Max leaf area(cm^2)	Seedling opening diameter(cm)
No-tillage with straw mulching	29.7	9.0	1.6	350	38.2
No-tillage uncovered	24.2	7.3	1.2	280	33.6
Conventional-tillage uncovered	28.1	8.8	1.4	320	35.4

Table 8 Effect of Cultivation pattern on characteristics of rapeseed yield components

Cultivation mode	Height (cm)	Branch point height(cm)	Branches		Pods per plant	Grains per pod	1000-grain weight(g)	Yield(kg/hm^2)
			first	second				
No-tillage with straw mulching	156.9	33.8	13.9	11.9	315.4	19.7	3.51	2677.5
No-tillage uncovered	156.8	32.7	9.8	4.7	279.3	16.8	3.47	2349.0
Conventional-tillage uncovered	157.3	32.5	13.6	11.3	305.8	18.9	3.52	2518.5

Effect of straw mulching on yield and it's component

The yield of no-tillage with straw mulching treatment increased and it's higher 13.9% than that of no-tillage uncovered

treatment, it's yield is 2677.5kg/hm^2. The yield of conventional-tillage uncovered treatment is higher 7.2% than that of no-tillage uncovered treatment, but it's difference is not significant. The yield of no-tillage straw mulching treatment is higher 6.3% than that of conventional-tillage uncovered treatment, but it's difference is not significant (Table 8).

The yield increase of no-tillage with straw mulching treatment result from the pods per plant (improved 12.9% compared with no-tillage uncovered treatment) and seeds per pod (improved 17.3% compared with no-tillage uncovered treatment), which the pods per plant is main action (Table 8).

Conclusion

There are good effects of no-tillage with straw mulching on improving soil structure. straw mulching can not only reduce soil water evaporation, but also improve the physical and chemical properties of soil. It was found that it can strengthen the ability of keeping soil water, stabilize soil moisture and temperature, and improve soil perviousness, increase soil fertility, such as the contents of available P and available K and soil organic matter. so to attain the purpose of fertilizing soil, improving soil, and stabilizing output.

The soil surface temperature can be increased and plants frozen rates can be decreased with straw mulching compared by uncovering treatments in the winter. At the some time, the soil water content can be improved with straw mulching. It is result from decreasing water evaporation from soil before soil surface whole uncovered by plants.

It can control field weeds and decrease the occurrence rate and diseased index of Virus disease and *sclerotinia sclerotiorum* and increase the yield and it's component such as pods per plant and seeds per pod in Rapeseed.

References

1.Singha G, Laryeab KB, Karwasrac S P,et al. Tillage methods related to soil and water conservation in south Asia[J]. Soil & tillage research, 1993, 27(1-4):273 - 282.

2.Moreno F, Pelegrin F, Fernándeza J E, et al. Soil physical properties, water depletion and crop development under traditional and conservation tillage in southern Spain [J]. Soil and tillage research, 1997, 41(1-2): 25 - 42.

3.Fuentes P,Juan Flury Markus, Huggins R,et al. Soil water and nitrogen dynamics in dryland cropping systems of Washington State, USA [J]. Soil and Tillage Research, 2003, 71:33-47

4.Unger, P.W. Organic matter, nutrient, and pH distribution in no-tillage and conventional-tillage semiarid soil[J]. Agron. J. 1991, 83:186-189

5. Li Lingling, Huang Gaobao, Zhang Renzhi, Effects of no-till with stubble retention on soil water regimes in rainfed areas[J], Journal of Soil and Water Conservation, 2005(5): 94-97

6.Zhu Zhonglin, Qing Mingfu,Zheng Jiaguo, Effect of water utilization efficiency under no tillage and straw mulching to wheat field and rape seeds field[J], Southwest China Journal of Agricultural Sciences, 2005(5):565-568

7. Wang Changquan, Wei Chengming, Li Ting, Effect of different zero tillage on the crop yield and soil property[J], Journal of Sichuan Agricultural University, 2001,19(2):152-154

8.Tang Yonglu, Huang Gang,Analysis of biological effect of the wheat sown through surface seeding and mulching straw[J],Southwest China Journal of Agricultural Sciences,2003(2):37-41

9.Gao Yunchao, Zhu Wenshan, Chen Wenxin, The relation between soil microbial biomass and the transformation of plant nutrients in straw mulched no-tillage soils [J]. Scientia Agricultura Sinica,1994,27 (6) :41-49

10.Shi Caixuan,Effect of no-tillage and tillage sowing on soil characteristics and rice growth, [J]Soil and Fertilizer, 1999(5)

11. Huang Jingfa, Effect of no-tillage sowing on soil fertility and rice growth, [J]Journal of Zhejiang Agriculture Sciences, 1997(5)

12. Nanjing soil research institute of Chinese Academy of Sciences, soil physical and chemical analysis [M], shanghai: Shanghai science and technology press,1998