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Effect of Different Furrow and Mulched Ridge on Water Moisture Conversation and Water Saving of Spring Mung Bean Planted Farmland

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Abstract

In order to understand the effects of different furrow and mulched ridge combined farming practices on water moisture conversation and water saving of spring Mung bean planted farmland, the study investigated the soil water contents, yield, water use efficiencies and economic efficiencies of spring Mung bean under five different furrow and mulched ridge combined farming practices in two consecutive years. The study found that during the whole growth period of spring Mung bean, the two year average 0-100cm soil water storage under the different farming practices significantly increased by 7.96-22.76mm compared with that under the flat farming practice (T-Test $P<0.05$), respectively. The two-year average seed yield under the different farming practices significantly increased by 0.63%-24.53% compared with that under the flat farming practice respectively. The annual WUEs and yield-based incomes and net incomes under the different practices increased by30.03%-68.80% and 27.66%-51.16% and 28.99%-78.92% compared with those under the control practice, respectively; and at the same yield of Mung bean, the percentage of saved water and water saving efficiencies of Mung bean increased by 22.73%-40.38% and 339.48-603.12RMB Yuan /hm^2 compared with those under the flat farming practice, respectively. The study indicated that double-furrow and mulched ridge combined water micro-collecting practice (practice 4) performed best in water retention and conservation, suitable to promote and adopt in semi arid regions and ecologically similar regions.

Keywords: spring mung bean, furrow and mulched ridge combined practice, water use efficiency, water saving efficiency

1. Introduction

Resistant to drought, low fertility, shade and with a short period of growth, Mung bean [*Vigna radiate (L.)*] produces highly nutritious and health-promoting seeds as an important grain and cash crop of China. it has two major production areas ,spring Mung Bean production area, which main covers Inner Mongolia, Jilin, Shanxi, Heilongjiang and Shaanxi, and Summer Mung Bean production area, which mainly involves Anhui, Henan, Sichuan, Hunan and Hubei, and now its planting area and yield are about 70×10^4 hm^2 and 1109 kg/hm^2, respectively.

Severely adverse environments, low and unevenly distributed rainfalls typical of arid regions and in particular droughts occurring at the seedling stage and the flowering to pod-setting stage are the important constraining factors to increase the yield of Mung bean and thus how to exploit limited rainfalls to the hilt and reduce invalid field water evaporation and increase the water use efficiency are the problems urgent to solve in Mung bean production.

Li F R et al (2000) revealed in study that in semi-arid regions, the rainfall, which ranges with 250～400 mm at the raining probability above 80%, mainly distribute in July, August and September and is characterized by low precipitations, high variability and uneven seasonal distributions. In the regions, the rainfalls do not temporally matches with the stages of crop growth and that mainly take the forms of light rain or rainstorm, which is not only unfavorable for crops to effectively take up water but causes water and soil losses in large areas, thereby leading to frequent drought incidences (Li & Gong, 2002). Thus, to exploit rainwater to capacity by rainwater collecting and water retaining and conserving to increase crop water use efficiency is the fundamental approach for the development of dry land farming (Yao & Yin, 1999; Li & Gong, 2001). Lots of researches on millet, corn and wheat showed that at proper furrow to ridge ratios, rainwater collecting systems are capable of increasing ground surface temperature and improving nutrient use efficiencies while the furrow and ridge combined farming was practiced (Guo, 2000; Li et al., 1997; Cao et al., 1994; Ding et al., 2007; Wang et al., 1999; Wang et al., 2007; Duan et al., 2006; Zhao et al., 1996). Ren et al (2008) held in study that furrow and ridge combined corn planting enabled corn to begin its growth and development earlier and got its plant height, leaf area and biomass significantly increased as well as its seed yields and water use efficiency significantly raised. Wang et al (1999) indicated in study that in semi-arid and drought-prone regions, the micro-collecting practice of rainwater enabled crop yield and water use efficiency to increase. Bai et al (2005) found in study that the water use efficiency increased by 69.77 % and104.8 % where the micro-collecting practice of rainwater was adopted compared with where the plastic film-mulched flat planting practice and the conventional planting practice were adopted, respectively. Lots of international and domestic researches showed that the furrow and ridge combined rainwater collecting practice for potato planting was well capable of increasing the yield and water use efficiency of potato (Wang et al., 2005; Xiao et al., 2010; Feng et al., 2011). However, there are no research reports on the rainwater micro-collecting practice for Mung bean. The study investigated the effect of different furrow and mulched ridge combinations on farmland soil moisture, yield, water use efficiency of Mung Bean as well as the water saving efficiencies of the combinations in order to provide theoretical basis for drought resistant and water saving planting of spring Mung bean.

2. Materials and Methods

2.1 Experiment Location

The experiment was carried out in the Zhaojiagou Demonstration Park of Dry land Farming, Shenmu, Yulin, Shaanxi located in the semi-arid area along the Great Wall. The semi-arid area is characterized by dry weather, high and dry terrains, and ground surface with poor warm-keeping and moisture-retaining capacities, and its soils are sandy loam and sandy soil. Part of the dominant and advantageous production areas, the area has an average annual rainfall of 440mm. in 2010 and 2011, the rainfalls of the area were 428.1mm and 354.5mm of which 310mm and 220mm distributed in the growth period of Mung bean (June to October), respectively.

2.2 Experiment Design

Beginning in the spring of 2010, the experiment lasted two years (2010 and 2011). The Mung bean variety of the experiment was Henshan Mung bean. The experiment had six treatments of which the planting arrangements are shown in Figure 1. here are the treatments:

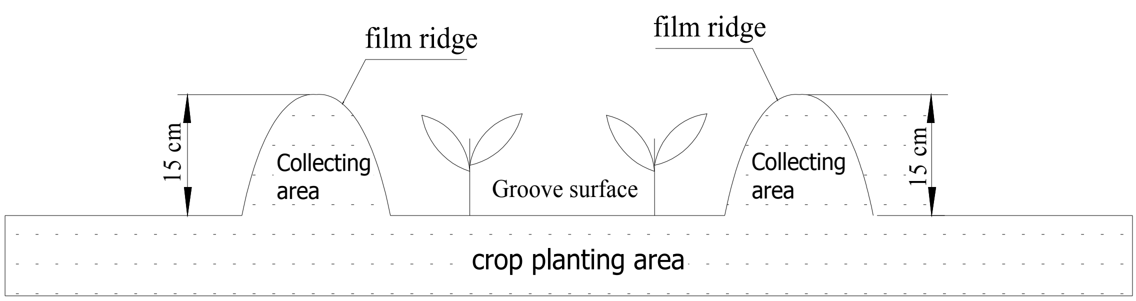

Figure 1. Sketch of the planting arrangements of the different furrow and mulched ridge combined rainwater micro-collecting practices

(1) Furrow and mulched ridge combined water micro-collecting practice (practice 1): the practice prepared farmland into160cm wide belts each of which was composed of one plastic film mulched ridge and one furrow. The plastic film was evenly spread on the ridge with both of its edges buried into soil five cm and thus left 65cm exposed. And the furrow was 85cm wide. The furrow had four rows of Mung Bean spaced 28 cm. the belt as a whole had an average row space of 40cm and an average plant space of 30cm, so that it had a plant density of 82500plant/hm^2. The size of plots for the practice were 6.4m×5m.

(2) Furrow and mulched ridge combined water micro-collecting practice (practice 2): the practice prepared

farmland into120cm wide belts each of which was composed of one plastic film mulched ridge and one furrow. The plastic film was evenly spread on the ridge with both of its edges buried into soil five cm and left 50cm exposed. And the furrow was 60cm wide. The furrow had three rows of Mung Bean spaced 30cm. and the belt as a whole had an average row space of 40cm and an average plant space of 30cm, so that it had a plant density of 82500plant/hm^2. The size of plots for the practice were 4.8m×5m.

(3) Furrow and plastic film-mulched ridge combined water micro-collecting practice (practice 3): the practice prepared farmland into80cm wide belts each of which was composed of one plastic film mulched ridge and one furrow. The plastic film was evenly spread on the ridge with both of its edges buried into soil five cm and left 40cm exposed. And the furrow was 30cm wide. The furrow had two rows of Mung Bean spaced 30cm. and the belt as a whole had an average row space of 40cm and an average plant space of 30cm, so that it had a plant density of 82500plant/hm^2. The size of plots for the practice were 3.2m×5m.

(4) Double-Furrow and plastic film-mulched ridge combined water micro-collecting practice (practice 4): the practice prepared farmland into 80cm wide belts each of which was composed of one plastic film mulched ridge on which there were two 30 cm spaced and 20 cm wide furrows dug. The plastic film was evenly spread to cover the ridge with both of its edges buried into soil five cm and left 50cm exposed. The furrows each had one row of Mung Bean hole sown. and the belt as a whole had an average row space of 40cm and an average plant space of 30cm, so that it had a plant density of 82500 plant/hm^2. The size of plots for the practice were 3.2m×5m.

(5) Hole sowing and plastic film-mulching combined water micro-collecting practice practice (practice 5): the practice prepared farmland into 160cm wide belts on each of which there were four rows of hole sown Mung bean. The belts were covered with plastic film two sides of which were buried into soil five cm and then left 50cm exposed. The average row and plant spaces were separately 40cm and 30cm, so that it the plant density was 82500 plant/hm^2. The size of plots for the practice was 3.2m×5m.

(6) The non-mulching flat farming practice (Ck or Practice 6).the practice adopted the flat farming for Mung bean. The row spaces and plant spaces of Mung bean were 40 cm and 30cm, respectively, and as a result the plant density of Mung bean was 82500plants /hm^2. The size of plots for the practice was 3.2m×5m.

2.3 Measurements and Measurement Methods

2.3.1Soil Water Content

The soil samples for soil water measurement were taken with conventional auger and oven dried and then their water contents were measured by oven drying and weighing. The sampling depth was 0-100cm and the sampling interval was 20cm. Soil sampling was done before sowing, at the seedling, flowering, pod-setting and maturing stages, and after harvesting respectively. After its harvest, the yield of Mung bean was calculated and the production value and water use efficiency of Mung bean was calculated according to its market price. The formulae for the different parameters were as follows (Shang et al., 2010; Zhao, 2004):

$$W=H\times D\times B\times 10$$

In which , W stands for soil water storage in mm, H stands for soil depth in cm, D stands for average soil bulk weight in g/cm^3, and B stands for soil water content in %. W_1

$$\Delta W=W_1-Y_1\times W_2/Y_2$$

in which, ΔW is the amount of saved water in m^3/hm^2 of a water micro-collecting practice in comparison with that of its control practice at the same yield of Mung bean. W_1 and Y_1 are the water consumption in m^3/hm^2 and economic yield of the control practice, respectively; and W_2 and Y_2 are the water consumption in m^3/hm^2 and economic yield in kg/hm^2 of the water micro-collecting practice, respectively.

2.3.2 Crop Water Consumption

$$ETa = P+U-R-F-\Delta W$$

In which , Eta stands crop water consumption (mm), P stands valid rainfall (mm), U stands for supplement from underground water (mm), R stands for runoff (mm), F stands for deep water seepage(mm), ΔW stands for water storage variation (mm) within the limits of experiment time. The water storage and crop water consumption in the formula were assumed to be the ones in 0-100cm soil. In the experiment location, the water table was very low, dozens of meters below ground surface in most cases, and thus the supplement from underground water and deep water seepage and ground surface runoff were negligible, so that the formula was simplified as $ETa=P-\Delta W$.

2.3.3 Crop Water Use Efficiency

$$WUE = Y/Eta$$

In which, WUE is the abbreviation of water use efficiency（kg • hm^{-2} • mm^{-1}）, ETa stands for crop water consumption (mm) and Y is the Yield of Mung bean（$kg \cdot hm^{-2}$）calculated in light of the total furrow / ridge covered area

2.4 Data Processing

SAS 8.01 was employed to carry out the ANOVA and the LST test was employed to test the difference significances（$P<0.05$ and Microsoft Excel was employed to do picture drawing.

3. Result

3.1 Soil Water

The soil water contents in 0-100cm soil seasonably varied remarkably different and were closely correlated with the growth stages of Mung bean and the rainfalls of the years in question (Figures 2 and 3).

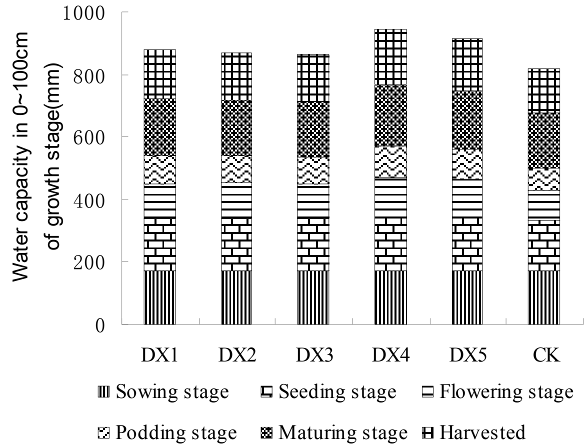

Figure 2. 0~100 cm Soil water storages at the different stages under the different practices in 2010

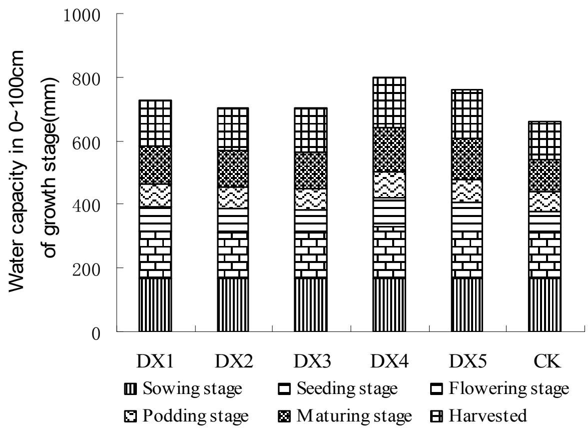

Figure 3. 0~100 cm Soil water storages at the different stages under the different practices in 2011

At the seedling stage, the soil water contents under the different water micro-collecting practices least differed from that under the control practice, which occurred in the two experiment years, because the seedlings did not have larger water requirements.

At the flowering and pod-setting stages , the soil water contents under all the water-collecting practices were the lowest and the soil water contents under the water micro-collecting practices significantly differed from that under the control practices in 0-100cm soil (by t test at $P<0.05$). Among all the practices, the double furrow and ridge combined water micro-collecting practice performed best in water saving.

At the maturing stage, the soil water contents under the different water micro-collecting practices were the highest. In 2010 and 2011, the 0-100cm soil water storage increments under micro-collecting practices 4,5,1,2 and 3 ranged within 1.75 -19.82 mm and 12.78 -39.10 mm compared with those under the control practice, respectively .

After harvesting the 0-100cm soil water contents under the different water micro-collecting practices significantly differed from that under the control practice (t-test at $P<0.05$). the furrow and ridge combined rainwater micro-collecting practices could not result in the complete depletion of soil water and thus the ensuing favorable soil water conditions could ensure seeding and healthy and strong seedling growth in the following year.

In the two years, the 0-100cm soil water storages under water micro-collecting practices 4,5,1,2 and 3 were 8.05-22.76 mm higher than those under the control practice, indicating significant differences (t-test at $P<0.05$). It follows that the furrow and ridge combined rainwater collecting practices performed well in water retention and conservation either in wet year (2011) or in dry year (2010) and Practice 4 performed best among all the practices.

3.2 Yield

Figure 4 shows that in 2010 and 2011, the yields under the different furrow and mulched ridge combined water micro-collecting practices increased by 0.63%-24.53% and 24.49%-48.09% compared with those under the control practice, respectively, and the yield under the double furrow and mulched ridge water micro-collecting practice appeared the highest among all the yields under the practices. The micro-collecting practices performed remarkably better in yield increasing in the dry year (2010) than in the wet year, indicating that the practices helped to use rainwater as much as possible by reducing the invalid field water evaporation and improving the water use efficiency, thereby increasing the yield of Spring Mung bean.

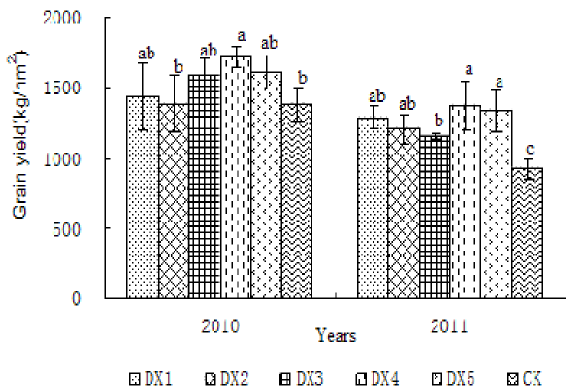

Figure 4. Grain yield of spring mung bean under different treatments

Table 1. WUEs of Mung bean against the different practices in 2010 and 2011

Year	Practice	Soil water at the sowing time (mm)	Rainfall (mm)	Soil water after harvesting (mm)	Total water consumption (mm)	Yield (kg/hm^2)	WUE [kg/ (mm/ hm^2)]
2010	Practice1	172.87	310.00	158.14	324.73	1437.50ab	4.43b
	Practice 2	173.34	310.00	149.94	333.40	1388.89b	4.17b
	Practice 3	166.21	310.00	123.45	352.76	1588.54ab	4.50b
	Practice 4	182.87	310.00	177.66	315.21	1718.75a	5.45a
	Practice 5	192.10	310.00	174.78	327.32	1614.58ab	4.93ab
	CK	179.42	310.00	153.06	336.36	1380.21b	3.31c
2011	Practice1	169.64	220.00	134.38	255.26	1291.67ab	5.06bc
	Practice 2	169.64	220.00	135.20	254.44	1209.72ab	4.75c
	Practice 3	169.64	220.00	141.46	248.18	1154.17b	4.65c
	Practice 4	169.64	220.00	165.87	223.76	1372.92a	6.14a
	Practice 5	169.64	220.00	152.57	237.07	1335.42a	5.63ab
	CK	169.64	220.00	128.59	261.05	927.08c	3.55d
Two year average	Practice1	171.26	265.00	146.26	290.00	1364.58bc	4.74c
	Practice 2	171.49	265.00	142.57	293.92	1299.31c	4.46c
	Practice 3	167.93	265.00	132.46	300.47	1371.35bc	4.58c
	Practice 4	176.26	265.00	171.77	269.49	1545.83a	5.79a
	Practice 5	180.87	265.00	163.68	282.20	1475.00ab	5.28b
	CK	174.53	265.00	140.83	298.71	1020.31d	3.43d

Note: in the same years, the different low case letters following the figures in the same columns indicated significant differences at p=0.05.

3.3 Water Use Efficiency

The water use efficiencies under the different furrow and mulched ridge combined water micro-collecting practices differed significantly from those under the control practice and varied in same patterns in the different years, i.e., the water use efficiencies under the double furrow and mulched ridge combined water micro-collecting practice (practice 4) appeared the highest, amounting to 5.79kg • hm^{-2} • mm^{-1} and increased by 68.8% compared with that under the Control practice, and the water use efficiencies under practice 5 followed the water use efficiencies under practice 4, amounting to 5.28kg • hm^{-2} • mm^{-1} , and increasing by 53.77% compared with those under the control practice (Table 1). The water use efficiencies under all the other practices differed from those under the control practice ($P < 0.05$). The two year research results showed that the different furrow and mulched ridge combined water micro-collecting practices were able to remarkably increase the water use efficiency of Mung bean and Practice 4 performed best in improving the water use efficiencies of Mung bean.

3.4 Economic Returns

Whether a water saving practice performs well in practice or not depends not only on its yield-increasing effect but also its economic return (Alexandrov & Hoogenboom, 2000; Zhang et al., 1994; Fang et al., 2006). It can be seen from Table 2 that the yield-based incomes and value cost ratios differed remarkably under the different furrow and mulched ridge combined water micro-collecting practices. The yield-based incomes and value cost ratios appeared the highest under Practice 4, followed by those under Practice 5 and the yield-based incomes and value cost ratios differed under practices 4 and 5 with under the control practice ($P<0.05$). the two year average yield-based incomes, net incomes and value cost ratios increased by 27.66%-51.16%, 28.99%-78.92% and 1.06%-19.58% under practices 1, 2, 3, 4 and 5, compared with those under the control practice, respectively.

Table 2.Yield based income and value to cost ratios against the different practices in 2010 and 2011-11-30

Year	Treatment	Agricultural input (yuan·hm^{-2})	Other input (yuan·hm^{-2})	Total input (yuan·hm^{-2})	Mung bean price (yuan·kg)	Yield-based income (yuan·hm^{-2})	Net incomes (yuan·hm^{-2})	Value to cost Ratio
2010	Practice1	1965	4050	6015	8.0	11500.00b	5485.00ac	1.91b
	Practice2	1965	4050	6015	8.0	11111.11b	5096.11ac	1.85b
	Practice3	1965	4050	6015	8.0	12708.33ab	6693.33ab	2.11ab
	Practice4	1965	4050	6015	8.0	13750.00a	7735.00a	2.29a
	Practice5	1965	4050	6015	8.0	12916.67ab	6901.67ab	2.15ab
	CK	1890	2850	4740	8.0	8908.33c	4168.33c	1.88b
2011	Practice1	2010	4150	6160	10.0	12916.67ab	6756.67ab	2.10abc
	Practice2	2010	4150	6160	10.0	12097.22ab	5937.22abc	1.96bc
	Practice3	2010	4150	6160	10.0	11541.67b	5381.67bc	1.87c
	Practice4	2010	4150	6160	10.0	13729.17a	7569.17a	2.23a
	Practice5	2010	4150	6160	10.0	13354.17a	7194.17a	2.17ab
	CK	1935	2950	4885	10.0	9270.83c	4385.83c	1.90c
Two years average	Practice1	1988	4100	6088	9.0	12208.33bc	6120.33bc	2.01bc
	Practice2	1988	4100	6088	9.0	11604.17c	5516.17cd	1.91c
	Practice3	1988	4100	6088	9.0	12125.00bc	6037.00bc	1.99bc
	Practice4	1988	4100	6088	9.0	13739.58a	7651.58a	2.26a
	Practice5	1988	4100	6088	9.0	13135.42ab	7047.42ab	2.16ab
	CK	1913	2900	4813	9.0	9089.58d	4276.58d	1.89c

Notes: the agricultural materials inputs included inputs in the forms of seeds, chemical fertilizers, and pesticides purchased at the subsidized prices. The other inputs included inputs in the forms of farming machinery and labors. In the same years, the different low case letters following the figures in the same columns indicated significant differences at p=0.05.

It can be seen from table 3 that at the same yield levels, the amounts and percentages of saved water under the different furrow and mulched ridge combined water micro-collecting practices differed among the different years so that the water saving efficacies under the practices remarkably differed. In the two years, the water saving efficiencies under practice 4 was the highest, followed by that under practice 5. The two year average percentage of saved water under practices 1, 2, 3 , 4 and 5 increased by 22.73%-40.38% and the two year average water saving efficiencies increased by 339.48-603.12RMB Yuan/hm^2 , compared with those of the control practices, respectively.

Table 3.Water-saving efficiencies under the different practices in 2010 and 2011

Year	Practice	Economic yield($kg \cdot hm^{-2}$)	Water consumption ($m^3 \cdot hm^{-2}$)	$\Delta W/(m^3 \cdot hm^{-2})$	β_W /%	Agricultural water price($yuan \cdot m^{-3}$)	Water-saving efficiency ($yuan \cdot hm^{-2}$)
2010	Practice1	1437.50ab	3247.30	817.86ab	24.32ab	0.5	408.93ab
	Practice2	1388.89b	3334.00	665.00b	19.77b	0.5	332.50b
	Practice3	1588.54ab	3527.60	880.50ab	26.18ab	0.5	440.25ab
	Practice4	1718.75a	3152.10	1318.78a	39.21a	0.5	659.39a
	Practice5	1614.58ab	3273.20	1099.60ab	32.69ab	0.5	549.80ab
	CK	1380.21b	3363.60	/	/	/	/
2011	Practice1	1291.67ab	2552.56	778.32bc	29.81bc	0.5	389.16bc
	Practice2	1209.72ab	2544.37	649.04c	24.86c	0.5	324.52c
	Practice3	1154.17b	2481.79	617.23c	23.64c	0.5	308.61c
	Practice4	1372.92a	2237.62	1091.86a	41.83a	0.5	545.93a
	Practice5	1335.42a	2370.68	956.81ab	36.65ab	0.5	478.41ab
	CK	927.08c	2610.51	/	/	/	/
Two year average	Practice1	1364.58bc	2899.93	815.35bc	27.30bc	0.5	407.67bc
	Practice2	1299.31c	2939.18	678.96c	22.73c	0.5	339.48c
	Practice3	1371.35bc	3004.69	750.33c	25.12c	0.5	375.17c
	Practice4	1545.83a	2694.86	1206.24a	40.38c	0.5	603.12a
	Practice5	1475.00ab	2821.94	1027.69ab	34.40ab	0.5	513.85ab
	CK	1020.31d	2987.05	/	/	/	/

Note: In the same years, the different low case letters following the figures in the same columns indicated significant differences at p=0.05.

4. Discussion

Furrow and mulched ridge combined farming practices are able to improve soil moisture of spring Mung bean planted farmland thereby exerting influence on the growth and development of spring Mung bean. Reiz et al (1988) adopted furrow and mulched ridge combined rainwater collecting practice for planting sorghum and millet in the Sahara desert region, with the yields of sorghum and millet reaching 1900.95 and 3101.6kg/hm^2, respectively, so that the practices had significant yield-increasing effects compared with the flat farming practice. Li et al (2001) revealed in study that under the rainwater collecting practice of mulching ridges with plastic film the crop yield got increased by 21％～92％. The results of the study showed that the furrow and mulched ridge combined farming practices had significant yield increasing effects and among the yields under these practices, the yield of Mung bean under practice 4 appeared the highest in the two years and increased by 48.09% compared with that under the control practice, and that the yield increments were higher in the dry year (2011) than in the wet year (2010).

Cai et al (2011) indicated in study that in the years with different rainfalls, the water storages in 0-2.0m soil tended to increase under the different mulching-integrated treatments in the period of fallow in winter and on the jointing and harvesting dates the straw rates increased, and the two year average net incomes under the three straw mulching-integrated treatments separately increased by 6.53%,16.89% and 15.95% Yuan/hm^2 compared with that under the treatment without integrating straw mulching ; and at the same yield levels, the percentages of saved water under the three straw mulching-integrated treatments separately increased by 5.14%,8.35% and 7.44% compared with that under the treatment without integrating straw mulching and the efficiencies under the three treatments increased separately by 50.07,81.31and 72.30 RMB Yuan /hm^2 compared with that under the treatment without integrating straw mulching. Plastic film mulching is capable of preventing soil water from evaporating, promoting deep soil water to move upwards and to be utilized, helping dry land crops absorb water, improving crop growth and development, accelerating the soil-plant-atmosphere transport, making crop yield significantly increase, and significantly improving crop water use efficiency(Wang et al., 1998). Zhang et al (2011) found in study that under the no-tillage and straw mulching combined farming practice, the highest yield and WUE of spring corn could reach 7251 kg/hm^2 and 2.41kg/m^3, respectively. The results of the study indicated that during the whole period of growth of Mung bean, the two year average water storages in 0-100cm soil under the different practices increased by 7.96-22.76 mm (t-test $P<0.05$) and the soil water contents in the soil layer differed remarkably between before and after raining. the the WUEs , yield based incomes , and net incomes and value to cost ratios under the different practices increased by 30.03%-68.80%, 27.66%-51.16% and

28.99%-64.79%compared with those under the control practice, respectively , and at the same yield levels , the percentages of saved water and the water saving efficiencies under the different practices increased by 22.73%-40.38% 339.48-603.12RMB Yuan/hm^2, respectively, and the practice 4 presented remarkable yield-increasing and income increasing effects, which indicated that the furrow and mulched ridge combined water micro-collecting practices had remarkable rainwater-pooling effects , capable of making ridge limited surface rainwater into crop-planted furrows as much as possible.

5. Conclusion

The furrow and mulched ridge rainwater micro-collecting practices could remarkably improve water conditions in 0-100cm soil during the growth period of Mung bean, promote Mung bean to use soil water, and significantly increase the yield, WUE and water saving efficiency of Mung bean, which was consistent in the two years; in the two years, Practice 4 performed best and the yields of Mung bean under the practice separately increased by 24.35% and 48.09%, compared with those under the control practice; and practice 5 ranked second in performance and the yields under the practice separately increased by 16.98% and 44.04% compared with those under the control practice.

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