Chapter 21
Effects of Plastic Mulch on Potato Growth

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Abstract Northern China is a major potato production region, and water-saving measures that can enhance both potato yield and quality play an important role in this region due to general water shortages. Plastic mulch has been used as an effective water-saving measure for potato cultivation in China. This chapter reviews the case studies on the effects of plastic mulching on potato growth, conducted at two areas of North China. Data from these experiments indicated that plastic mulching could save irrigation water and reduce evapotranspiration in most cases. Daily mean soil temperature under mulch was 2–9°C higher than that without mulch, especially during the early growth stage. However, as the plant canopy enlarged, the soil temperature difference between mulched and non-mulched plots became smaller. Plastic mulch could restrain or enhance potato plant growth during the early growth, dependent on the microenviromental air and soil temperatures. The possible negative effects of plastic mulching included a lower emergence, lower potato tuber yield, and poorer tubers quality, which may be attributable to the poorer soil aeration and detrimentally high soil temperature associated with plastic mulch when the air temperature is high. As mulch duration is an influential factor, data from these case studies suggested that 60 days of mulching duration was most favorable for potato production in the tested areas. Mulch removal after 60 days was proposed to avoid subsequent negative effects. To complement the current knowledge on the plastic mulching research, future research should be focused on the hydrothermal dynamics and its effect on potato growth with different drip irrigation regimes under plastic mulching conditions.

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21.1 Introduction

China is currently the world's leading potato-growing country, and potatoes are widely cultivated across China (Wei 2005). Northern China is a major potato production region and potatoes are generally planted in raised beds and furrow-irrigated. However, frequent droughts, general water shortages and poor irrigation management often lead to low yields and poor tuber quality. Therefore, water-saving measures that can enhance both potato yield and quality play an important role in this region (Wang et al. 2006).

Soil mulching with plastic film, which results in reduced water loss and more regulated soil temperature, has been widely used in agriculture (Li et al. 2004a). Additional benefits of plastic mulching can include decreased nitrate leaching (Schmidt and Worthington 1998; Bowen and Frey 2002; Romic et al. 2003), increased crop yields (Romic et al. 2003; Tiwari et al. 2003; Xie et al. 2005; Ramakrishna et al. 2006), increased death of pathogens (Vos et al. 1995; Triki et al. 2001), suppressed weeds (Ramakrishna et al. 2006; Ghosh et al. 2006), lessened soil bulk density (Anikwe et al. 2007), and enhanced use of rainwater (Tian et al. 2003). At the same time, the negative effects of mulching are rather notable. Tiquia et al. (2002) and Li et al. (2004b) found that the CO_2 content in the soil under mulch was much higher than in non-mulched areas, which means poor soil aeration and a detriment to potato growth (Phene and Sanders 1976). There are controversial reports on potato yield being impacted when plastic mulch is used, with yield reduction reported in some studies (Liang et al. 1998; Baghour et al. 2002), but yield increases in other studies (Cheng and Zhang 2000; Sun and Li 2004). As this yield variability might be attributed to differences in climatic conditions (Doring et al. 2005), information is needed on how potato growth would be affected by plastic mulch in Northern China. Therefore, researchers at China Agricultural University have conducted field research on the effects of plastic mulch on potato growth, began in 2001 and 2006 in North China Plain, and continued from 2006 to 2010 in Northwestern China (Wang et al. 2009, 2011; Hou et al. 2010). This chapter reviews these research activities with particular focus on the effects of mulching-drip irrigation regimes on potato growth.

21.2 Irrigation Water and Evapotranspiration

The total irrigation amounts varied with the year and irrigation criteria (Tables 21.1 and 21.2). At the Luancheng (Hebei Province) Agro-ecosystem Station, Chinese Academy of Sciences in 2001, mulching duration was for 60 days after planting with six drip irrigation frequencies with the same amount of irrigation water for all the mulched treatments. The non-mulched treatment (M0F1) had 20 mm more irrigation than the mulching treatments. Precipitation was 77 mm, which was normal for the local climate. Potato evapotranspiration (ET, the sum of soil surface evaporation and crop's transpiration) among the mulching treatments were in a range from 236 to 249 mm, showing little impact by irrigation frequency (Table 21.1).

Table 21.1 Seasonal rainfall precipitation, irrigation amount, and evapotranspiration in mm for each irrigation treatment at two sites of North China Plain (Wang et al. 2009)

Year	Treatment	Precipitation	Irrigation	Evapotranspiration
2001	M60F1	77	172	249
	M60F2	77	172	236
	M60F3	77	172	247
	M60F4	77	172	246
	M60F6	77	172	243
	M60F8	77	172	248
	M0F1	77	192	275
2006	M50	81	–[a]	–
	M70	81	–	–
	Mw	81	–	–
	M0	81	–	–

Treatment codes are defined as M: with plastic mulch of 0, 50, 60, and 70 days after planting, and the entire growing season (w), respectively. F: drip irrigation with once every (F1), 2 (F2), 3 (F3), 4 (F4), 6 (F6) and 8 (F8) days
[a]No data available

However, ET for the non-mulched treatment (M0F1) was 26–39 mm more than the mulched treatments. At the Tongzhou (Beijing) Farmland Water Cycle and Modern Water-saving Irrigation Experimental Station, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences in 2006, precipitation was 81 mm, which was very close to that at the Luancheng (Hebei Province) Agro-ecosystem Station as both sites are in the North China Plain. Unfortunately, the data of irrigation and soil water changed were unavailable (Wang et al. 2009).

At the Xuebai Experimental Station of Minqin Agricultural Extension Center of Gansu, precipitation in 2006 was 56 mm, which was less than normal in the region. In 2007, however, precipitation was 170 mm, nearly doubled the normal amount. The average ET of all treatments in 2006 was 121 mm less than that in 2007. In both the growing seasons, treatment M0 without plastic mulching received the most irrigation water and had the highest ET. Similarly, higher irrigation amounts and potato evapotranspirations without plastic mulch were observed in the 2008, 2009, and 2010 seasons at Shiyanghe Experimental Station for Water-Saving in Agriculture and Ecology, China Agricultural University, Wuwei, Gansu province in the same arid region of Northwest China (Table 21.2). These data confirmed the effectiveness of plastic mulching in reduction of irrigation water as this technique reduced the severity of the dry and windy climate and the strong soil surface evaporation under non-mulched conditions, especially early in the growing season (Chakraborty et al. 2008; Wang et al. 2003, 2009).

As shown in Table 21.2, irrigation ranged from 303 to 359 mm in 2008, from 127 to 200 mm in 2009, and from 177 to 312 mm in 2010. Irrigation during 2009 and 2010 was less than in 2008 due to more abundant and more effective rainfall and the selective reduction of the SMP criteria during parts of the growing season. In 2009, treatments MS2, MS3 and MS4 had less irrigation than MS1, implying that the lower soil matric potential (SMP) criterion, −35 kPa, could save irrigation water no

Table 21.2 Seasonal rainfall precipitation, irrigation amount, and evapotranspiration in mm for each irrigation treatment during five potato growing seasons at two sites in Gansu Province (Hou et al. 2010; Wang et al. 2011)

Year	Treatment	Precipitation	Irrigation	Evapotranspiration
2006	M0	56	330	428
	M60	56	250	361
	M75	56	260	357
	M90	56	250	371
	M105	56	260	391
	Mw	56	290	385
2007	M0	170	284	527
	M40	170	284	512
	M60	170	257	491
	M90	170	265	522
	Mw	170	245	564
2008	F1	54	359	465
	MF1	54	359	476
	MF2	54	339	448
	MF4	54	303	424
	MF8	54	338	447
2009	S1	97	200	336
	MS1	97	190	331
	MS2[a]	97	175	298
	MS3	97	147	289
	MS4	97	127	262
2010	S1	63	312	343
	MS1	63	296	314
	MS2	63	305	335
	MS3	63	259	258
	MS4	63	177	243

M: with plastic mulch of 0, 40, 60, 75, 90, and 105 days after planting, and the entire growing season (w), respectively. F: drip irrigation with once every 1 (F1), 2 (F2), 3 (F3), 4 (F4), and 8 (F8) days. S1: irrigation threshold at −25 kPa soil matric potential (*SMP*) at the three growth stages; S2: irrigation threshold at −25 kPa *SMP* at potato initiation and bulking stages and −35 kPa *SMP* at maturing stage; S3: irrigation threshold at −25 kPa *SMP* at potato initiation and maturing stages and −35 kPa *SMP* at bulking stage; S4: irrigation threshold at −35 kPa *SMP* at the three growth stages

[a]Irrigation amount of MS2 was unexpectedly higher than MS1. This should be experimental error caused by spatial variability of soil water (Wang et al. 2011)

matter at which potato development stages the criterion was used (Wang et al. 2011). In 2008, the mulched treatments irrigated once every 2, 4, and 8 days received less water than the mulched and non-mulched treatments with daily irrigation due to irrigation delays caused by rain.

Potato ET ranged from 424 to 476 mm in 2008, 262 to 336 mm in 2009, and 243 to 343 mm in 2010 season (Table 21.2). Since more irrigation water was applied in 2008, the ET values in 2008 were higher than that in 2009 and 2010. In 2008, the highest ET occurred in the treatments with the highest irrigation frequency; water use from plants under mulch was comparable to the non-mulched treatment, which is similar to the results of Kang et al. (2004). The highest ET (476 mm) was found in treatment MF1, slightly higher than F1. Tolk et al. (1999) and Xie et al. (2005) also reported similar results. They both attributed the greater water use to the higher leaf area index where the crop was grown with plastic mulch.

21.3 Soil Temperature Changes with Plastic Mulching

In an experiment carried out in 2006 at the Xuebai Experimental Station at the Minqin Agricultural Extension Center in Gansu Province, a typical arid region of Northwest China, Wang et al. (2009) observed that daily mean soil temperatures under mulching conditions was 2–9°C higher than non-mulching conditions, especially during the early growing period (Fig. 21.1). The effects were more apparent in the top 5 and 10 cm soil layers. As the plant canopy enlarged, more soil surface was shaded and the soil temperature difference between mulching and non-mulching decreased. During mid-July, the difference at 25 cm soil depth even became negative. Finally, as the plant stems and leaves senesced, the difference became positive again. The soil temperature variations under plastic mulching conditions were consistent with previous observation for potato (Ma and Li 1996; Cheng and Zhang 2000) and further confirmed in 2007 between mulched and non-mulch potato beds by the same research group (Hou et al. 2010).

Kar and Kumar (2007) suggested that a maximum temperature above 30°C could inhibit tuber growth. Thus, Wang et al. (2009) recorded daily soil highest temperature at 2:00 pm. The daily soil highest temperature at 5 and 10 cm depths were above 30°C during the period from early May to late June, which was when tuber initiation and tuber bulking occurred. A maximum temperature of 42°C was reached at 5 cm

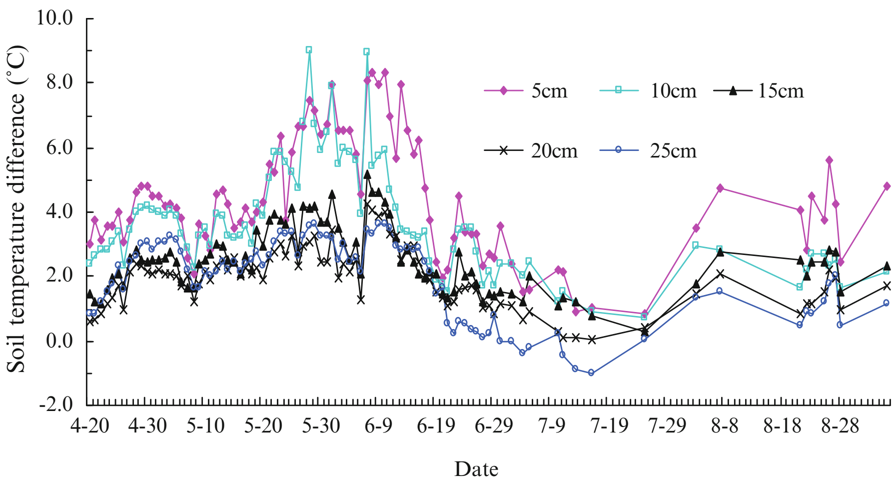

Fig. 21.1 Difference in daily mean soil temperature at different soil depths between potato beds with and without plastic mulch (Wang et al. 2009)

depth during these days. After that, highest daily soil temperature gradually fell within a range from 30.2°C to 20.0°C as potato canopy continued to enlarge. In the last phase (throughout August), soil temperature rose again regardless the falling of air temperature. The higher soil temperatures under plastic mulch during the middle of the day could have been detrimental to potato seed piece health and spouting, explaining the observation on a lower potato emergence rate with plastic mulch than that under no-mulch conditions (Wang et al. 2009).

21.4 Effects of Plastic Mulch on Potato Plant Height

Inconsistent effects of plastic mulching on plant height were observed in the early experiments conducted in the North China Plain (Wang et al. 2009). At the Luancheng Agro-ecosystem Station, in 2001, potato plant height without plastic mulch was higher than with mulch during the early growing period. After removing the mulch, the difference of crop height became smaller with little difference during the late growing period. In another experiment conducted at the Tongzhou (Beijing) Farmland Water Cycle and Modern Water-saving Irrigation Experimental Station, in 2006, however, plant heights without mulch were lower than those with mulch during the early growing period, but became similar during the late growing stage. Wang et al. (2009) noticed that the maximum air temperature during the early growing period in the 2001 experiment was typically higher than 30°C at Luancheng area, and therefore the soil temperature under mulch conditions was probably too high to detrimental to potato plant development (Kooman et al. 1996); however, soil temperature data was not recorded.

The results of the three experiments conducted in the arid Gansu Province of Northwestern China are more consistent, showing the promotion of plant height by plastic mulching (Wang et al. 2009; Hou et al. 2010). In both the 2006 and 2007 growing seasons, early season plant heights without plastic mulch were lower than those with mulch (Fig. 21.2). During the later growing period, the air and soil temperatures were higher as there were 51 and 41 days mostly in June–August (Wang et al. 2009; Hou et al. 2010), the further raising soil temperatures by mulching, which could be detrimental to potato plant elongation and tuber growth (Kooman et al. 1996; Kar and Kumar 2007). Thus, with the earliest mulch removal in 2006, plant height of treatment M60 was significantly greater than other mulched treatments ($P < 0.05$). Other mulched treatments had very similar plant heights and the difference among these treatments was not significant. This suggested that later mulch-removal had little effect on plant height. In 2007, however, it was found that mulching duration had significantly ($P < 0.01$) affected plant height during the early growing period (From June 6 to June 26): M0 < M40 < M60 < M90 ≈ Mw. This height difference could be explained by the mild higher soil temperature under mulch, which enhanced stem elongation according to Marinus and Bodlaender (1975). In June, the average highest air temperatures were 29.3°C and 28.5°C in 2006 and 2007, respectively (Hou et al. 2010). Later in 2008, 2009, and 2010 seasons

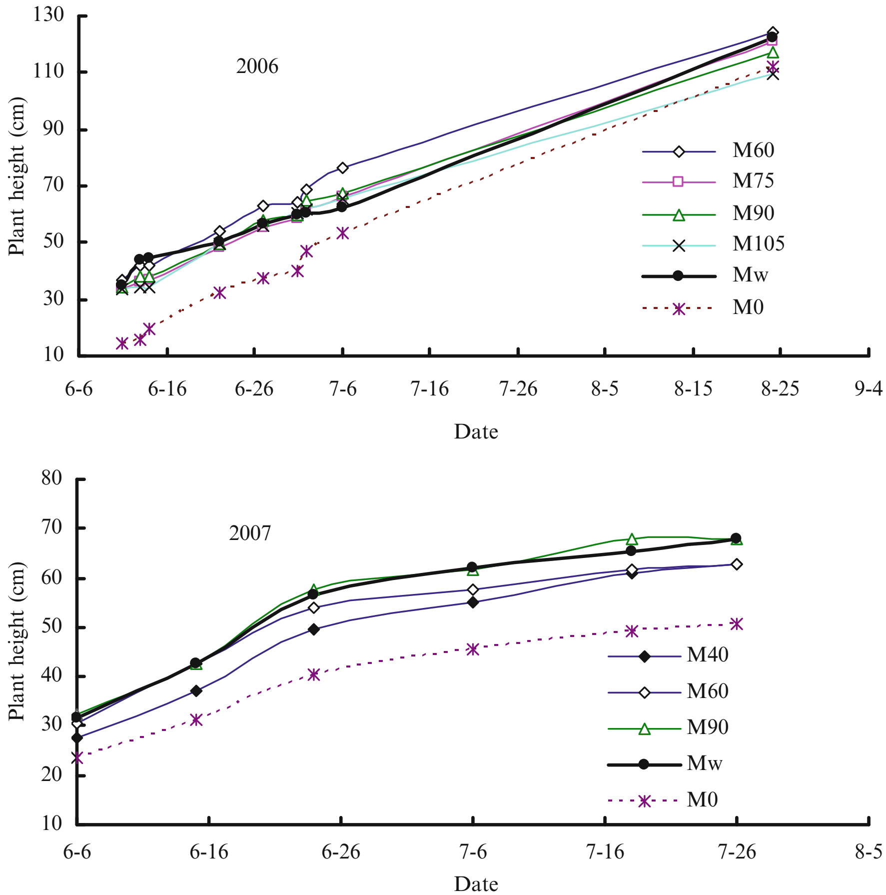

Fig. 21.2 Potato plant heights affected by the plastic mulching durations in the 2006 and 2007 growing seasons. Mulching durations are M0, M40, M60, M75, M90, M105, and Mw for 0 (control), 40, 60, 75, 90, and 105 days after planting, and the entire growing season , respectively (Hou et al. 2010)

with experiments conducted at a nearby experiment station, the same researchers (Wang et al. 2011) consistently observed that plant heights without plastic mulch were lower than those with mulch under various experimental conditions.

21.5 Tuber Yield and Water Use Efficiency (WUE)

In the two experiments conducted at two sites in North China Plain, the tuber yields in the plots without plastic mulch were 21.2 and 26.0 Mg ha^{-1}, respectively (Wang et al. 2009). The average tuber yields in the plots under different plastic mulching conditions in the two sites were 14.6 and 24.1 Mg ha^{-1}, respectively, both lower than the yields without plastic mulch. More than that, none of tuber yields in any plot with plastic mulch was higher than that in the corresponding control plat without mulch. The authors (Wang et al. 2009) proposed two possible explanations for the observation. One is the higher soil temperature under mulch, which was almost above the optimum (18°C) for tuber growth (Hay and Allen 1978); another is the lower emergence rates under mulch. Thus, the authors (Wang et al. 2009) concluded that plastic mulch may have negative effects on tuber growth in North China Plain. Plastic mulch has been widely used in North China, especially where there is very limited rain resources for water saving. Based on these experimental results, plastic mulching should not be used for potato production in this Plain. But we suggested more field trials should be done to get an unequivocal conclusion and determine the cause of the decreased yield.

At Xuebai Experimental Station of Minqin Agricultural Extension Center of Gansu Province, the yield in 2007 was much lower than in 2006, mainly because there were many more cloudy days in 2007 (Hou et al. 2010). Mulching the soil for 60 days (M60) had the highest (2006) or among the highest yields (2007). However, tuber yield decreased as the mulching duration got longer than 60 days (Table 21.3). In the meantime, all the mulched treatments had higher WUE than the non-mulched treatment and WUE also decreased as the mulching duration got longer in 2006. M40 had lower yield than M60 and regression suggests that slightly longer mulching durations than 40 days from planting were beneficial. Both the tuber yield and WUE suggest that the early plastic mulching was beneficial, and 60 days of mulching duration seemed to be most favorable for potato growth.

In the subsequent experiments at the nearby Shiyanghe Experimental Station for Water-saving in Agriculture and Ecology, Wang et al. (2011) observed inconsistent impacts of plastic mulching on potato tuber yields. Similar to the observations in the two sites of North China Plain (Wang et al. 2009), the control without mulch, F1, had the highest potato yield in 2008 (Table 21.3) as the yield in treatment F1 was 9.9%, 14.8%, 15.0% and 16.2% higher than the mulched treatments MF1, MF2, MF4 and MF8, respectively. The highest potato tuber yield was also observed in the treatment without mulch in 2009. Yields of treatments in MS1, MS2, MS3 and MS4 were 23.3%, 19.7%, 8.5% and 27.0% lower, respectively, than that in S1. In 2010, there is an exception as the highest potato tuber yield was obtained in treatment MS2. This was due to the fact that this treatment inadvertently received the most irrigation water (Wang et al. 2011). Potato tuber yield in the treatment without mulch (S1) was higher than any other mulched treatments in 2010.

WUE values ranged from 136 to 186 kg ha^{-1} mm^{-1} in 2006, from 59 to 86 kg ha^{-1} mm^{-1} in 2007, 68to 77 kg ha^{-1} mm^{-1} in 2008, 80 to 109 kg ha^{-1} mm^{-1} in 2009, and 96 to 115 kg ha^{-1} mm^{-1} in 2010 (Table 21.3). In 2009, WUE in S1 was 27.5% higher than the corresponding mulched treatment MS1, a similar result to the difference between F1 and MF1 in 2008. The results in 2008 and 2009 are consistent with the results in 2006 and 2007 that plastic mulch may negatively affect WUE if it is not removed in a timely manner (Hou et al. 2010).

The effect of irrigation frequency on WUE in F1 was 13% higher than the corresponding mulched treatment (MF1) in 2008. Similar to the earlier observation (Wang et al. 2009), the effect of irrigation frequency on potato WUE with plastic

Table 21.3 Potato tuber yield and water use efficiency during five potato growing seasons at two sites in Gansu Province (Hou et al. 2010; Wang et al. 2011)

Year	Treatment	Yield (Mg ha −1)	WUE (kg ha −1 mm −1)
2006	M0	58.2	136
	M60	66.3	184
	M75	58.8	165
	M90	56.3	152
	M105	55.9	143
	Mw	54.2	141
2007	M0	30.9	59
	M40	37.0	72
	M60	42.0	86
	M90	41.2	79
	Mw	39.4	85
2008	F1	35.7	77
	MF1	32.5	68
	MF2	31.1	69
	MF4	31.0	73
	MF8	30.7	69
2009	S1	34.4	102
	MS1	26.4	80
	MS2	27.6	93
	MS3	31.5	109
	MS4	25.1	96
2010	S1	35.3	103
	MS1	34.5	110
	MS2	38.6	115
	MS3	29.7	115
	MS4	23.3	96

M: with plastic mulch of 0, 40, 60, 75, 90, and 105 days after planting, and the entire growing season (w), respectively. F: drip irrigation with once every 1 (F1), 2 (F2), 3 (F3), 4 (F4), and 8 (F8) days. S1: irrigation threshold at −25 kPa *SMP* at the three growth stages; S2: irrigation threshold at −25 kPa *SMP* at potato initiation and bulking stages and −35 kPa *SMP* at maturing stage; S3: irrigation threshold at −25 kPa *SMP* at potato initiation and maturing stages and −35 kPa *SMP* at bulking stage; S4: irrigation threshold at −35 kPa *SMP* at the three growth stages

mulch was not clear. This observation is in contradiction with the effects of irrigation frequency on potato WUE without mulch as high frequency irrigation enhanced potato tuber growth and WUE (Wang et al. 2006).

21.6 Potato Tuber Quality

Data from tuber grading analysis indicated that the number of marketable tuber (W ≥ 50 g) was affected by mulching (Table 21.4). Mulching reduced marketable tubers per plant in 2006, but increased marketable tubers per plant in 2007 season.

Table 21.4 Potato tuber grades impacted by plastic mulch treatments

	Total tubers (plant^{-1})	Marketable tubers (plant^{-1})[a]	Total tuber weight (g plant^{-1})	Marketable tuber weight (g plant^{-1})
2006				
M0	–[b]	8.1	1,420	1,347
M60	–	6.7	1,603	1,551
M75	–	5.8	1,386	1,326
M90	–	6.7	1,382	1,286
M105	–	6.1	1,382	1,310
Mw	–	4.9	1,441	1,392
2007				
M0	6.8	4.3	629	572
M40	7	4.5	595	538
M60	7.7	4.9	733	667
M90	8.6	4.8	675	606
Mw	8.9	5.4	735	659

Mulching durations are M0, M40, M60, M75, M90, M105, and Mw for 0 (control), 40, 60, 75, 90, and 105 days after planting, and the entire growing season, respectively. Data are adapted from Hou et al. (2010)

[a]Tuber weight not less than 50 g each

[b]No data available

Consistently, mulching duration affected tuber quality as treatment M60 had the heaviest marketable tubers in both seasons. The yields of the marketable tubers were then reduced with mulching duration either shorter or longer than 60 days. The pattern of the yields of the marketable tubers (Table 21.4) is in the same trend of the total tuber yields impacted by mulching (Table 21.3). It is apparent that plastic mulch was beneficial to potato growth during the early growth stage shown by mean early emergence and plant height (thus aboveground biomass) because the air temperature was relatively low and mulching could increase temperature to an extent not restraining potato growth. As air temperature went high, the negative effects of plastic mulch became dominant: higher soil temperature and poorer soil aeration were both detrimental to tuber growth.

Wang et al. (2011) further measured several quality parameters for the potato harvested in 2008, 2009, and 2010 growing seasons (Table 21.5). No substantial differences were found in tuber firmness between the non-mulched and the corresponding mulched treatments in the 3 years, suggesting that this quality index was not affected by mulch. However, potatoes grown without plastic mulch (F1 and S1) always had higher tuber specific gravity, starch content, and vitamin C content than those grown with plastic mulch (MF1 and MS1). This observation suggests that plastic mulching negatively affected the three quality parameters. Lower tuber quality could be due to the poorer soil aeration and higher temperature associated with plastic mulch as such circumstances were not conducive to the accumulation of biomass and nutrients (Mendoza and Estarda 1979; Ge and Zhang 2003; Li et al. 2004b; Guo et al. 2008).

Further analysis of those mulching data revealed that potato tuber nutrient content increased with the increased irrigation frequency, consistent with published

Table 21.5 Potato tuber quality for the different irrigation treatments with plastic mulching

Year	Treatment	Specific gravity	Starch content (%)	Vitamin C content (mg·100 g^{-1})	Tuber firmness (MPa)
2008	F1	1.080 a*	13.91 a*	25.96 NS	1.986 NS
	MF1	1.074 ab	12.68 ab	23.38	2.028
	MF2	1.071 ab	12.04 ab	22.00	1.999
	MF4	1.071 ab	11.92 b	21.08	1.964
	MF8	1.066 b	10.96 b	19.71	2.038
2009	S1	1.080 NS	13.98 NS	29.00 NS	1.861 NS
	MS1	1.069	11.77	24.00	1.768
	MS2	1.077	13.20	21.00	1.814
	MS3	1.075	12.82	20.33	1.786
	MS4	1.076	13.16	27.67	1.773
2010	S1	1.080 a	14.00 a	28.50 a	1.100 b
	MS1	1.066 b	10.83 b	24.80 ab	1.130 b
	MS2	1.072 ab	12.29 ab	22.54 ab	1.170 a
	MS3	1.078 a	13.41 a	21.24 b	1.090 b
	MS4	1.073 ab	12.32 ab	22.55 ab	1.120 b

M: with plastic mulch. F: drip irrigation with once every (F1), 2 (F2), 3 (F3), 4 (F4), and 8 (F8) days. S1: irrigation threshold at −25 kPa soil matric potential (*SMP*) at the three growth stages; S2: irrigation threshold at −25 kPa *SMP* at potato initiation and bulking stages and −35 kPa *SMP* at maturing stage; S3: irrigation threshold at −25 kPa *SMP* at potato initiation and maturing stages and −35 kPa *SMP* at bulking stage; S4: irrigation threshold at −35 kPa *SMP* at the three growth stages. Data are from Wang et al. (2011)

NS difference among different treatments is not significant, F-test ($P > 0.05$)

* Difference among different treatments is significant by F-test ($P < 0.05$). Values in a column with the same letter are statistically similar according to Duncan's multiple range test ($P < 0.05$)

data (Zhou et al. 2004). Wang et al. (2011) assumed that high-frequency irrigation created a more humid soil environmental conditions where the potato tuber grew, favoring nutrient uptake by tuber roots. In 2009, no significant difference was found in any of the four quality indexes among the SMP treatments. The tuber specific gravity and starch content in treatment MS2 were slightly higher than those in the other mulched treatments. In 2010, however, treatment MS3 rather than MS2 had the highest tuber specific gravity and starch content among the mulched treatments. Tuber specific gravity and starch content for treatment MS3 were significantly higher than MS1. These findings were different from the results in 2009. For vitamin C content, no significant differences were found between any of the mulched treatments, implying that the irrigation threshold change by SMP had little effect on vitamin C content. Tuber firmness, was greatest in treatment MS2 among all the mulched treatments and was significantly greater than any other treatment. Günel and Karadoĝan (1998) reported significant increases in specific gravity, dry matter, starch content, chip yield and significant decreases in protein content and oil absorption rate of chips by frequent irrigations at early planting-stolen initiation and stolen initiation-tuber bulking growth stages. However, they found frequent irrigations at the final tuber bulking growth stage had deleterious effects on specific gravity, dry matter, starch content and chip yield especially when irrigation continued until maturity. Thus, further research should be focused on more sophistic experiments of drip irrigation schemes to elucidate accurate impacts of plastic mulching on potato quality in the arid region of Northwest China.

21.7 Conclusion

This chapter examines the case studies on the effectiveness of plastic mulching for potato production under drip irrigation in two typical regions of Northern China. Results suggest that daily mean soil temperature under mulch was 2–9°C higher than without mulch. The mulch effect on soil temperature was greatest during the early growth and became less as the plant canopy increased. Mulch reduced irrigation water and evapotranspiration. Reduction of soil matric potential irrigation criterion from −25 kPa to −35 kPa during tuber bulking and maturing stage could enhance water use efficiency, but the constant irrigation threshold of −35 kPa could lead to lower water use efficiency. However, inconsistent results were obtained on the effects of potato growth and tuber yield with reduction of this irrigation criterion to −35 kPa during tuber bulking stage.

Both tuber yield and water use efficiency demonstrated benefits from early plastic mulching. The possible negative effects of mulching included a lower emergence, lower potato tuber yield, and fewer marketable tubers per plant. Plastic mulch can also negatively affect tuber specific gravity, starch content, and vitamin C content. These quality parameters were less affected by plastic mulching with higher irrigation frequency. During the later part of the growing season, the negative effects (i.e. poor soil aeration and potentially higher soil temperature higher than the optimum for potato growth) may outweigh water saving effect of plastic mulch. These case studies suggested that 60 days of mulching duration was most favorable for potato production in the experimental regions. Mulch removal after 60 days is apparently necessary in order to avoid subsequent negative effects.

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