The effects of different mulch types and irrigation intervals on cotton yield

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Auswirkungen unterschiedlicher Materialien zur Bodenbedeckung und unterschiedlicher Bewässerungsintervalle auf den Baumwollertrag

1 Introduction

Limitation of water resources is a cause of crop production decreasing in agricultural systems especially in arid and semi-arid regions. Many approaches have been proposed to provide crop water requirements and alleviate the impacts of water shortage on plant production. Surface-applied mulches reduce soil water erosion, thus enhancing the potential for increasing water conservation, which is highly important for improving dry land crop production in a semi-arid region (UNGER, 2001). Straw mulch can be considered as an agronomic input with the potential to ameliorate stress by reducing evaporation of moisture from the soil and increasing infiltration rate (LAL, 1975). It has also been reported to lower soil temperature (BENOIT and KIRKHOUN, 1963), while a negative consequence can be to impede seedling emergence (CHOPRA and CHAUDHARY, 1980). Many materials have been used as mulch (UNGER, 1995). Chaff leaves (crop residues), manures, papers, glass-wool, thin layer plastics, polyethylene compounds and chemical and oil derivate by-

Zusammenfassung

Die Erhaltung von landwirtschaftlichen Kultursystemen setzt eine Steigerung der Ressourceneffizienz voraus, besonders der Wasserressourcen in ariden und semiariden Regionen. In der Absicht, die Effekte unterschiedlicher Materialien zur Bodenbedeckung und unterschiedlicher Bewässerungsintervalle auf die Keimungsrate und den Gesamtertrag von Baumwolle zu untersuchen, wurde ein Experiment durchgeführt, bei welchem vier Mulchtypen (wasserabsorbierende chemische Polymere, Dung, Häcksel und Polyethylen) sowie zwei unterschiedliche Bewässerungsintervalle (7 bzw. 14 Tage) Verwendung fanden. Die Ergebnisse zeigten höchste Baumwollerträge und höchste Keimprozente bei Polyethlyen bzw. Häcksel zur Bodenbedeckung. Die Ergebnisse bei wasserabsorbierenden chemischen Polymeren waren statistisch nicht signifikant von der Kontrollvariante zu unterscheiden. Die vorliegenden Ergebnisse zeigten schließlich, das Häcksel besser geeignet ist zur Bodenbedeckung wegen der Verfügbarkeit, der geringen Kosten, aus arbeitstechnischen Gründen sowie aus Gründen der biologischen Abbaubarkeit.

Schlagworte: Mulch, Rückstand, Polyäthylen, aquasorb Polymer, RCBD.

Summary

Sustaining the agricultural systems need to increase resource use efficiency, especially water resources in arid and semi-arid regions. In order to evaluate the effects of different mulch types and irrigation intervals on germination rate and total yield of cotton an experiment was conducted with four types of mulches (consisted of water absorbent chemical polymers, manure, chaff and polyethylene) and two irrigation intervals (7 and 14 days).The results indicated highest values of cotton yield and seed germination percentage for polyethylene and chaff mulches, respectively, but differences between control treatment and water absorbent mulch (as lowest values) were not significant for any studied traits. Our final results showed chaff manures are more suitable, because of availability, cost, and labor and biodegradability considerations.

Key words: mulch, residue, polyethylene, aquasorb polymer, RCBD.

products are many kinds of common used mulches to water storage and saving in envisaged regions by water shortage. These kinds of mulches have been used in a wide range of environments and variable situations.

Crop residues are used most commonly because of availability, cost and labor considerations. On the other hand, dry land crops often don't produce sufficient residues (Straw, Stover etc.) to result in large increases in water storages. Also, crop residues often are used as animal feed, fuel, etc. where residues are limited for whatever reason, and other material could be replaced as mulches to fulfill mentioned goals. For these materials to become acceptable for disposal on land, they should be in a form that are not dispersed by wind and doesn't cause the land to have a trashy appearance. The application of farmyard manure, also, has been reported to improve soil physical and chemical conditions and to help conserve soil moisture (TRAN-THUC-SON et al., 1995). Therefore one of proposed approaches to cope water shortage and consequently increase yield is application of different kinds of mulches to cover soil surface or around the crop roots. Many objects such as soil erosion and weed invasion control, in companion with improvement of water infiltration and water saving by decreasing evaporated water from soil surface have been followed to extend and improve mulch systems in crop production systems, especially in arid and semi arid regions. These are just many advantages of mulches to improve water use efficiency in crop production systems and other agricultural systems.

2 Material and methods

A field study was conducted in suburbs of Kashan (51° 27' N, 32° 59' E) at an elevation of 982 m. Iran, with annual temperature mean of 18.8 °C and long term precipitation mean of 130 mm/year. The field was uniform and had a loam soil texture, which furrowed two years before planting and gave up free during these two years. Cottonseeds were sown in a completely randomized block design with four replications. Plots (4 by 2.4 m) were hand seeded at 15 April in 75cm-rows (at 5 plants m^{-2}). The space within individuals was 35cm. All crop management factors were applied uniformly to the entire site and fertilization was done according to advised quantities. Irrigation was done based on furrow irrigation and two fixed irrigation intervals as a factor with two levels (7 or 14 days) was considered in this regard. In order to facilitate germination of seeds, they were soaked in water for 24 hours and then were removed and used. Germination was occurred 6 days after sowing. Emerged seedlings were counted 15 days later and then plots were thinned to required density.

The studied factors were different kinds of mulches in 4 levels (consisted of water absorbent chemical polymers (M1), manure (M2), chaff (M3) and polyethylene (M4) which were compared by control treatment without mulching (M0)) and two irrigation intervals (7 and 14 days). Chaff and manure mulches were used in a quantity of 10 and 20 $kg.m^2$, respectively, while water absorbent polymer mulch was sprayed by combining of original compound (1 kg) with 350 liters of water per hectare. RCBD was performed on treatments after planting for chaff, manure and water absorbent polymer mulches, but before planting for polyethylene mulch.

Biomass production was measured at 35 days after sowing and cotton yield was measured twice (two picking stages), 135 days after sowing and 25 days after first picking. To do measurements, individuals were cut at the soil surface and removed from the plots. After carrying by sampling paper bags to laboratory, were weighted by ordinary digital balance (with accuracy of ± 1 gr). Sampling method was same for all plots and treatments.

This experiment was aimed to evaluate the effects of different kinds of mulches and different irrigation intervals on the yield and biomass production of cotton. Collected data were analyzed with analysis of variance and mean values for measured traits were compared by Duncan's multiple range test using SAS program (SAS INSTITUTE, 1989).

3 Results and discussion

Monthly precipitation and temperature amounts during the study are shown in (Fig. 1). Precipitation was not occurred from July to September, while the temperature increased during this period. The results of analysis of variance on germinated seeds No (Fig. 2) indicated that the effect of both irrigation intervals and mulch kinds were significant at 1 % of probability level. Figure 2 shows the number of germinated seeds (with total number of 105 seeds/row). Measured values for germinated seeds were 51.9, 54.5, 62.5, 83.1 and 90.8 % for M0, M1, M2, M3 and M4 respectively. Results indicated the highest values for polyethylene and chaff mulches, respectively, which can be related to seed laying moisture (resulted from better water saving) and more appropriate seedbed temperature. The lowest germinated seeds number was related to water absorbent polymer and control treatments (with non significant statistical differences in 1 % of probability level). The lower value for control and water absorbent polymer treatments can be related to ineffective water saving for control treatment and lower soil temperature for water absorbent polymer.

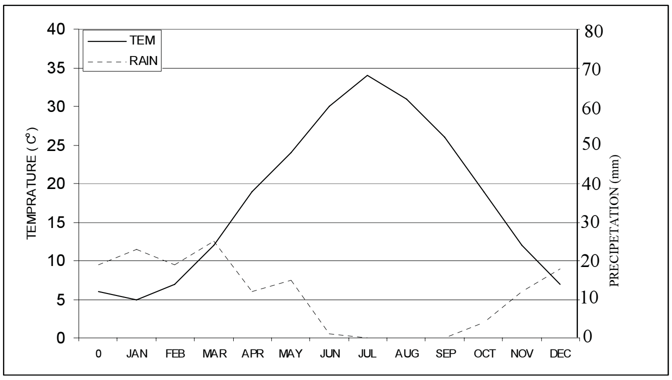

Figure 1: Monthly precipitation and temperature amounts during the study
Abbildung 1: Monatlicher Temperaturverlauf und Niederschlagsmengen während des Experiments

Biomass production was also affected by exerted treatments (table 1). The difference between control and water absorbent polymer as the lowest values was not significant, while differences between all other ones were significant

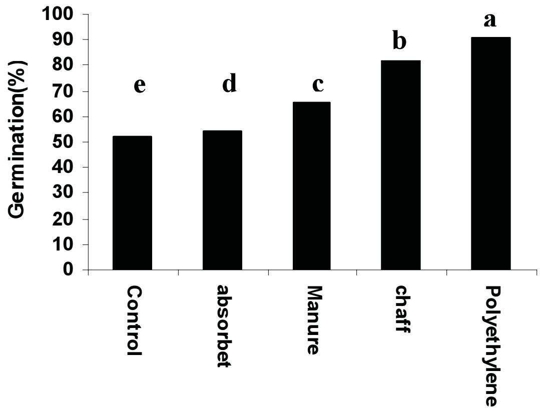

Figure 2: Germination percentages of cotton seeds under different mulches types
Abbildung 2: Keimungsprozente von Baumwollsamen unter unterschiedlichen Materialien zur Bodenbedeckung

and the highest value belonged to polyethylene mulch. Mean comparisons also indicated higher biomass production under shorter irrigation interval by the side of polyethylene mulch. The lowest biomass production was seen in control and water absorbent polymer treatment under 14 days irrigation interval. Same results were seen for other important traits such as 1^{st} and 2^{nd} pick stages yield and total yield, too (table 1).

Our results on 1^{st} cut yield indicated higher values for 7 days than 14 days irrigation intervals. Also, in respect to

Table 1: Mean comparisons for simple and combined effects of studied treatments on many important traits of cotton (the difference of means including same letter(s) are not significant)
Tabelle 1: Durchschnittsvergleiche für einfache und kombinierte Effekte der untersuchten Behandlungsvarianten im Bezug auf bedeutende Merkmale der Baumwolle. (Die Unterschiede der Mittelwerte mit gleichen Buchstaben sind nicht signifikant.)

Irrigation	**1^{st} cut**	**2^{nd} cut**	**total yield**	**biomass**	**germination**
7 days	502.5 a	411.5 a	914.0 a	2532.5 a	74.9 a
14 days	474.4 b	276.0 b	750.4 b	2102.1 b	63.3 b
Mulches	**1^{st} cut**	**2^{nd} cut**	**total yield**	**biomass**	**germination**
M0	305.0 d	310.0 d	615.0 d	1704.1 d	51.9 d
M1	322.5 d	323.8 d	646.2 d	1789.3 d	54.5 d
M2	400.0 c	372.5 b	772.5 c	2190.0 c	65.2 c
M3	684.7 b	300.0 c	984.7 b	2786.5 b	83.1 b
M4	729.9 a	412.5 a	1142.4 a	3117.4 a	90.8 a
Irrigation * Mulches	**1^{st} cut**	**2^{nd} cut**	**total yield**	**biomass**	**germination**
7 days M0	355.0 d	345.0 de	695.0 c	1920.4 e	58.7 c
7 days M1	350.0 d	375.0 cd	725.0 c	2002.0 e	61.2 c
7 days M2	422.5 c	432.5 b	855.0 d	2475.6 d	72.2 b
7 days M3	662.5 b	395.0 c	1057.5 b	2891.4 b	89.3 a
7 days M4	727.4 a	510.0 a	1237.4 a	3373.2 a	92.3 a
14 days M0	260.0 f	275.0 f	435.0 f	1487.7 f	45.2 d
14 days M1	295.0 e	272.5 f	467.5 f	1576.1 f	47.9 d
14 days M2	377.5 cd	312.5 e	690.0 e	1904.3 e	58.2 c
14 days M3	707.0 ab	205.0 g	912.0 c	2680.6 c	77.0 b
14 days M4	732.5 a	315.0 e	1047.5 b	2861.7 b	88.4 a

mulch treatments, the highest 1st cut yield was belonged to polyethylene mulch (7, 46, 56 and 59 % more than chaff, manure, water absorbent and control). Mean comparisons on the simple effects of mulches on the 1st cut yield indicated that all kinds of mulches, excluding M0 and M1, had significant differences. Also, mean comparisons of combined treatments (Irrigation and mulch interactions) showed that polyethylene mulch (without respect to irrigation interval) had been the best choice to increase cotton yield (table 1).

Analysis of variance on the 1st cut yield revealed significant differences between different kinds of mulches and different irrigation intervals. These results were true for 2nd cut yield and total yield in the end of growing season, too. Also; mean comparisons for 2nd and total yield confirmed these results. Total yield of treated plots by polyethylene mulch was more than other mulch treatments (14, 33, 44 and 47 % more than chaff, manure, absorbent polymer and control, respectively). Also, mean comparisons of total yield for different irrigation intervals revealed higher values for shorter one, which can be related to provide more water for crop and secure water requirement during growing season. It should be noted that some biases in mean comparisons for 1st and 2nd pick stage yield could be related to indeterminate nature of cotton development that can be a source of variations between picking stages (table 1).

The results indicated that different mulch types had significant interactions with irrigation intervals. Polyethylene mulch plus 7 days irrigation intervals caused considerable increase in total yield in comparison with un-mulched treatment plus 14 days irrigation interval (×2.84). Also, all studied traits were not significant between control treatment and water absorbent polymer. Also, results indicated that although application of mulches can be useful and advisable to improve cotton yield, but we should be care about appropriate mulch to use, because non-favorable selection on mulch type can increase production costs, but not farmer's income. Increasing of irrigation intervals in all mulch treatments resulted in decreasing of yield, which could be related to low precipitations during active growing season of cotton as showed in figure 1. BADARUDDIN et al. (1999) showed that mulch and extra irrigation of wheat in Sudan and Mexico (as two hot environment with low relative humidity) resulted in yield increasing. DONG ZHIONG (1998) also referred to positive effects of straw mulch on water saving and decreasing of evaporation. Increasing of cotton yield, when polyethylene mulch was used to cover soil surface, was reported by DONG ZHIONG, 1998. The results of DOUGLAS et al. (1999) revealed that application of polyethylene mulch have been able to increase soil water content and consequently melon yield. These results were seen in other report by DONG ZHIONG (1998). They found that both polyethylene and straw mulches can improve soil water content, soil temperature and consequently wheat yield. Similar results have reported for tomato and organic mulch by MITCHELL et al. (1999).

Also, it has been suggested that plastic mulching can be effective in improving the yield, quality and reliability of crop in marginal climatic areas for the growth of maize (PHILIPPS, 1994). Manipulating early season soil temperature by plastic mulch also has improved the yield and quality of sweet corn (FELCYZNSKI, 1994). HAUNG et al. (2005) also indicated that straw mulch have been able to increase wheat yields during both dry and wet conditions. They showed that straw mulch decreased evapotranspiration, soil water depletion and increased water use efficiency. Their final results showed that higher crop yields in semiarid regions can be achieved by using irrigation or proper combination of straw mulch and irrigation.

RAMAKRISHNA et al. (2005) in the study of the impact of mulch treatments and explore economically feasible and eco-friendly mulching options (the effect of three mulching materials consisted polythene, rice straw and chemical mulch on weed infestation, soil temperature, soil moisture and pod yield in groundnut) found that mulching materials showed different effects on soil temperature.

Polythene mulch increased the soil temperature by about 6 °C at 5 cm depth and by 4 °C at 10 cm depth. Higher values for germinated seeds in treated polyethylene mulch in our experiment, too, can be related to more suitable temperature of seedbed for germination. Also it should not be forgotten that polyethylene (and other mulch types) have another advantages, too, which can improve crop yield. SCOTT GREEN et al. (2005) gauge the effect of black polyethylene mulch (poly mulch) across a range of site conditions and found that on marginal sites poly mulch may provide an attractive management option in both intensive and minimal weed-control applications.

One of other reasons for non significant differences between control treatment and water absorbent polymer in a wide range of studied traits can be related to failure to achieve greater soil water storage was attributed to precipitation absorption by the polymer, especially after they disintegrated, which resulted in same evaporation from bare and treated soil by water absorbent polymer. Similar results have reported by UNGER (2001).

Our final results indicated that application of different mulch types to save the water and achieve other related advantages is dependent to prevalent climatologically conditions especially precipitation quantity and distribution. Also, polyethylene and straw mulches application not only had no harmful effect on the soil, but also, increased cotton yield significantly. Hence, these kinds of mulches can be disposed of on croplands, but it should not be forgotten that these should be economically acceptable and environmentally friendly. On the other hand, straw mulches are more suitable, because of availability, cost, labor and biodegradability considerations. Undoubtedly, success of these kinds of agronomic practices is dependent on the balance of related costs and incomes.

Using the appropriate mulches is one of new horizons of soil conservation and sustainable agriculture which should be study more and more to detect the short and long term impacts of them on arable lands and decision making about be or not to be?

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