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Review/Overview Article

Mulching for microclimate modifications in farming–An overview

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ABSTRACT

Mulch kept on or applied to the soil modifies crop microclimate above and within the soil as well as above and within the mulch. Residue retention, mulch application and/or live mulch planting are few methods followed by farmers throughout the world. These mulches modify crop microclimatic aspects, viz. solar radiation, reflection and absorption, shading, thermal radiation, temperature, humidity, wind/ air movement, evaporation (crop and soil), soil moisture (surface and within) and crop composition, structure and growth. They have marked effects on the soil–residue–atmosphere interfaces, depending on the characteristics of the residues, soil moisture and temperature alterations simultaneously, and modifications in the plant physiological functions due to environmental conditions created by mulches.

Key words **:** Microclimate, Mulching, Soil hydrothermal regimes

As early as the 1960s, Adams (Adams 1965; 1967; 1970) carried out series of experiments on the benefits of mulching. The word mulch has been probably derived from the German word "molsch" means soft to decay, which apparently referred to the use of straw and leaves by gardeners as a spread over the ground as mulch (Jacks *et al*., 1955). Subsequently, Unger (1978) proved that wheat (*Triticum aestivum* L.) straw mulching after wheat harvesting substantially reduced soil temperature and benefitted succeeding sorghum [*Sorghum bicolor* (L.) Moench] crop. Stigter (1984a) proposed the definition for mulch as "any shallow layer that appears at the interface of soil and air with properties that differ from the original soil surface layer". Mulching produces new microclimates in the original soil, in each new layer thus created and in the layer of air that covers the new surface (Baldy and Stigter, 1997). For example, the transmittance of global solar radiation through mulch of crop residues must be considered to understand the influence of surface material on the energy balance and temperature of the underlying soil and the overlaying material and air in conservation tillage systems (e.g. Tanner and Shen, 1990; Baldy and Stigter, 1997). Zero tillage with surface mulch has been found to be a promising alternative to conventional tillage and gave higher yield as a consequence of improved water conservation (Lal, 1983; Tomar *et al.,* 1992; Franzen *et al.,* 1994). One of the major advantages associated with straw mulching is retaining greater availability of soil water by controlling evaporation loss from the soil surface and improving water infiltration (Chen *et al.,* 2007; Qin *et al.* 2006; Sharma *et al.,* 2011). These are covered here in details.

Residue retention, mulch application and live mulch planting

Reduced or no-till systems commonly leave all or part of the residues from the previous crop on the soil surface, which influences heat and water balance of the soil profiles over a growing season (Gupta *et al.*, 1981). Conservation tillage, either minimum or no-tillage, a component of conservation agriculture, has the objective of maintaining enough residues and/ or planting enough crops on the soil to protect against wind and water erosion [Unger and McCalla, 1981; Sharratt and Campbell, 1994; Baldy and Stigter, 1997; examples from China with grassland live mulch and in Kenya with agroforestry in Stigter (2010)].

An example of live mulch and stubble for wind-and water-erosion protection in China has been enumerated by Stigter (2010a). In China, the ecological term of "ecotone" is used to indicate the region between full grazing and full cultivation in arable farming. Our foothills region is such

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an ecotone with annual precipitation from 250 to 400 mm and topography of gentle hills, located to the north of Yinshan Mountain in Inner Mongolia. Since the middle of the nineteenth century, the ecotone consisted of grassland with interspersed cereal growing. Environmental degradation made the "ecotone" since the 1980s the poorest area of the whole of Inner Mongolia. Only in the 1990s did cultivated fields expand (close to 50%) and the numbers of animals double. To combat this poverty situation, firstly water erosion on hills was overcome by replacing traditional slope planting into contour ploughing and planting. (Zheng *et al.,* 2005). The Wuchuan Dryland Farming Experimental Station then developed an approach with a hill as a unit, in which in ecotone areas with sufficient rainfall the top of hills is used for no-grazing or low-grazing grassland restoration. The lower slopes, less than 15%, are designated for contour fields with strip intercropping, and the valleys for pure strip intercropping, leaving stubble in the winter in alternating fields, with annual rotations. This was widely applied by farmers. After some years, cropped fields are rotated with grassland for animal husbandry in controlled grazing, increasing restoring capacity from wind erosion. Cropping is intensified while more area is returned to grassland, compensating farmers with cereals and money in the form of cash. Advice is given to reduce the cropping/ grassland ratio when the rainfall decreases from south to north in the ecotone area. In the middle belt areas, with less rainfall, strip intercropping of grasses and crops could be allowed. Where rainfall is lower still, grass with shrubs under controlled grazing is promoted as a main undertaking, with only little intensive agriculture on flat land, like in earlier times.

Mulching may be positive for the seedbed, yet thick layers may prevent germination of seeds that positively respond to light and to temperature fluctuations (Fenner and Thompson, 2005) and can deter establishment and performance of shaded emerged seedlings (Facelli and Pickett, 1991; Suding and Goldberg, 1999). Thus, mulch has three main possible effects on plant recruitment: facilitative and inhibitory (Eckstein and Donath, 2005; Fehmi and Kong, 2012; Loydi *et al.,* 2013) or neutral (Chambers, 2000; Wilson *et al.,* 2004).

An example of mulch use with agroforestry in Kenya was described by Stigter (2010b). Kassod tree [*Senna siamea* (Lam.) Irwin e Barneby] contour hedgerows with interrow distances of 4 m were compared 'on-station' for erosion control on a 14% slope of an Alfisol, intercropped in rotation with maize (*Zea mays* L.) and cowpea [*Vigna unguiculata* (L.) Walp.], without the use of fertilizers. There were 4 rows of maize or 6 rows of cowpea in the alleys formed by the hedgerows. Hedgerows were cut to a height of 25 cm, 2 weeks before the onset of the rains, and the prunings spread uniformly over the soil surface (Stigter, 2010). Cumulative results for 4 consecutive seasons showed that the most successful treatment for soil loss and run-off reduction was the combination of hedgerows and surface spreading of their prunings as mulch, just before the start of the 2 annual rainy seasons. This reduced cumulative run-off from close to 100 mm to only 20 mm and reduced cumulative soil loss from more than 100 t/ha to only 2 t/ha. This was at the expense of 35% of the maize yields but only 25% of the cowpea yields, because mean rainfall was above average during the 2 cowpea seasons. These rather high-yield depressions were due to higher competition because of aging of the hedges that had also been used in earlier experiments, along with fertilizers. The planting of hedgerows alone, without applying the mulch, was appreciably less effective in both soil loss and run-off reduction, at the expense of even more maize yield. Mulch appeared the main soil evaporation-reducing factor, but under high soil evaporation of between 50% and an upper limit of 65% of rainfall, it was not more than in the order of between a relative 5 and 10%, due to the low biomass growth in semi-arid conditions (Ofori and Kyei-Baffour, 2012). Removal of surface mulch resulted in an additional cumulative loss of 56 mm, but the presence of the hedgerows was much less important in reducing run-off, e.g. only an extra 23 mm was saved. *See* also Kinama *et al.* (2007).

Crop microclimate

Microclimate refers to the climate just above and within the crop canopy and in the soil root zone that can be influenced by day-to-day management practices at various time scales (e.g. Stigter, 1994a).The best crop microclimate is one that provides the most favourable environment for the desired plant response, that is, the response that maximizes crop productivity. Key plant responses to microclimate can be managed for either radiation balances/ budgets, heat balances/ budgets and/ or moisture balances/ budgets (Stigter, 1994b).

Solar radiation is the prime source of energy for evapotranspiration which is controlled by the crop microclimate. Transpiration is necessary but soil evaporation is an inescapable evil to harvest the end-product (Kinama *et al.,* 2005). The few plant characters deciding the penetration of radiation are plant density, architecture (the form and structure of the branches and leaves), and row alignment (Stigter, 1994b). Soil-moisture budget is decided by the incident solar radiation on the soil, while the presence of crop residues in and on the soil can be a major factor deciding crop water use and soil-moisture budgeting (Stigter, 1994b).

Traditionally, over the ages unconsolidated organic materials such as bark or straw were used as mulches/crop residues for modifying the soil thermal properties (Stigter *et al.*, 1987; Stigter *et al.,* 2005). According to Slick and Curtis (1983), in another, narrower definition, a mulch is 'a protective layer of organic or inorganic material left on or near the soil surface as an aid in stabilizing the surface and improving soil microclimate conditions for establishing vegetation'. The reason for mulch use here is more limited compared with Stigter's (1984a) definition. The seedbed microenvironment in soils with partial surface mulch cover will be affected by the width of the bare row zones (Bristow and Abrecht, 1989; Oteng'i *et al.,* 2007). Manipulating residue or soil colour for soil coverage may also be a means of altering the microclimate in agricultural production systems (Stigter *et al.,* 1984a and the physics behind it in Stigter *et al.*, 1984b; Sharratt and Campbell, 1994; case study in Stigter, 2010). Several authors (Stigter, 1984a; 1984b; Sharratt and Glenn, 1988; Awal and Ikeda, 2002) have proven the effect of different types of these mulch materials, especially indigenous mulches, for beneficially manipulating the microclimate (e.g. Stigter *et al.*, 1984c), although unpleasant side-effects have occasionally been reported (Othieno *et al.,* 1985).

This concept has a wide acceptability in dryland and rainfed ecosystems through alteration of soil thermal properties and microclimate (e.g. Ghauman and Lal, 1985; Stigter, 1994a), but it assumes centre stage in irrigated ecosystems too. Residue retention in lieu of soil coverage restricts the transport of water vapour from soil surface to plant climate, diminishes the direct evaporation loss of soil water (Xie *et al.,* 2006; Yuan *et al.,* 2009) and increases water availability to the crops (Fuchs and Hadas, 2011). In addition to water conservation and erosion prevention, conservation agriculture as the new form of agriculture has an inbuilt principle of residue retention for soil coverage with a minimum cap of 30%, ostensibly with other benefits like weed suppression too. Mulching decreases the absolute humidity during the night. Therefore, the increase of relative humidity at night caused by mulching is mainly due to lower air temperatures, which increased dew formation (Jacks *et al.,* 1955) too. However, also during the day the higher albedo of straw mulch than that of soil may lead to decreased surface and air temperatures, especially when the soil is dry (Döring *et al.,* 2006). It may also be mentioned that an increase of soil organic matter not only may be beneficial to water-holding capacity of the soil but also to its nutrient conditions and as a form of carbon sequestration (Dumanski *et al.*, 2010). An example of carbon sequestration issues: zero tillage, residue management, grassland (live mulch) and grazing management was presented by Dumanski *et al.* (2010).

Recently, there have been significant improvements in farm-management practices with a resulting increase in the carbon efficiency of agricultural production (Dumanski *et al.,* 2010). Mitigation of climate change in agriculture requires adoption of integrated farming systems, since these capture the synergism of multiple practices and have the potential to reverse the decline and actually increase the soil organic carbon (SOC) pool. Practices such as zero tillage (ZT) have the combined effect of soil-carbon sequestration, while concurrently reducing fossil fuel use and improving biodiversity. Other mitigation measures include agronomic practices such as improved crop varieties, improved crop rotations, and improved fertilizer management. Better residue management and water management in rice can yield significant reductions of CH_4 emissions. For livestock, there are a wide range of practices associated with grazing land management. The IPCC identified 3 land-use systems with significant global potentials for climate-change mitigation, agroforestry, improved grassland management, and restoration of severely degraded lands. Verchot (2007) evaluated these options, and identified agroforestry and grassland management as the best options. Improved grassland management, despite the low carbon densities in this land-use system, has a high potential because of the large land areas suitable for these improvements (3.4 billion ha). Improved carbon sequestration in grasslands can be achieved through introduction of more productive grass species and legumes, improved livestock management, proper stocking and improved nutrient management. About 60% of the grazing lands suitable for improved carbon sequestration are in developing countries. These land-use systems are also effective in helping small-scale farmers adapt to climate change, because they reduce their vulnerability to interannual weather variability and changing climatic conditions.

Soil-residue-atmosphere interface

Microclimate is composed of the water, temperature, wind and radiation regimes which often interact to induce a number of responses on the biological systems linked with a particular microclimate. The disposition of the downward atmospheric thermal radiation and the upward propagation of thermal radiation toward the sky from the soil involve absorption and re-emission of thermal radiation by the residue elements, as well as radiation directly transmitted through the gaps in the residue. However, in day-time clear weather the top parts of the mulch, that itself works as an insulation layer, will be much higher in temperature than lower parts and then the air above the mulch, and send more thermal radiation than it receives (Stigter, 1994a). At night cloudiness determines the exchange rate of thermal radiation as anywhere else. Radiation and sensible heat interact to modify the temperature profile in the residue (Stigter, 1985a; Shen and Tanner, 1990). An understanding of the physical transport processes at the soil-residue-atmosphere interface (Stigter *et al.*, 1984c; Stigter, 1985b; Hatfield and Prueger, 1996) aids in the management of crops under conservation agriculture. The physical effects occur due to changes in the surface short-wave reflectivity, or albedo, and an increase in the stagnant air resistance to vapour and/or heat diffusion. Subsequent studies by Wagner-Riddle *et al.* (1996) formulated that there is a decrease in the energy available to the soil from global solar radiation, and reduced amounts of heat entering the soil from the radiation-warmed residue or from warmer air above. Later, Liu *et al.* (2014) were of the opinion that mulching of or residue retention on the soil has a significant impact on the hydrological and biological processes of soil ecosystems, with specific emphasis on the soil–plant–atmosphere continuum (SPAC) water cycling and soil thermal regimes.

Characteristics of residue

Amount of residue, its density and thickness, percentage of ground cover, as well as its short–wave reflectivity, porosity and tortuosity are a few of the mulch characteristics that determine (Van Doren and Allmaras, 1978) differences in soil moisture and thermal regimes. In addition to the above, spectral characteristics of plastic covers dictate the undercover soil temperatures (Al-Karaghouli *et al.,* 1990). The surface colour of the mulch material may have a distinct advantage in the surface reflectivity (Stigter, 2010b). An example of colour, determining reflection of the surface, used to advantage was presented by Stigter (2010b). Early snow melting through surface spread of soil material (India) is an example of attempts to study traditional techniques of microclimate improvement for a better understanding and for possible transfer to otherplaces, eventually in a modified form. It is therefore among advices such as in design rules on above-and below-ground microclimate management and manipulation, but may also be considered as a form of agrometeorological assistance to land management. This is an age-old practice followed since the Epic Mahabharatain Lahaul and Spiti district of Himachal Pradesh. Farmers still utilize this practice of spreading the soil on snow for early melt of snow. This helps in early vacation of the fields for land preparation for the sowing of different crops. Darker soil absorbs more solar heat than white snow and this heat is partly conducted downward, causing faster melting of the snow by about 8–30 days, depending upon amount of snowfall received during the season. This helps in early sowing of the crop(s) and enables the sowing of a second short-duration crop like buckwheat [*Fagopyrum esculentum* Moench], rapeseed (*Brassica napus* L.) or mustard [*Brassica juncea* (L.) Czernj & Cosson]. This case is a marvelous example of traditional ‘mulching’ changing the albedo (surface reflection) of the surface. It is of course very helpful to be able to take on a second short-duration crop in snow-bound areas. It is good to know that this example is already documented in an ICAR publication ‘*Validation of Indigenous Technical Knowledge in Agriculture*’ on collection of documentation and validation of indigenous technical knowledge. A comparative study for willow ash and fine-textured soil with respect to their amount and efficacy was also already undertaken.When Stigter had started in Dar es Salaam to look around for examples of traditional knowledge and indigenous technologies that could be physically dealt with, he developed an outdoor demonstration experiment on the effect of soil albedoon on soil surface temperature. This education-related work was published by Stigter *et al.* (1984a). He also developed a physical theory on these phenomena (Stigter *et al.*, 1984b). Finally, we used this approach to explain temperatures under mulched tea, by expressing the thermal efficiency of grass mulches as apparent soil albedos (Stigter *et al.*, 1984c; Othieno *et al.*, 1985).

While lighter colour of the residues favours reflection of the sun light by its very surface parts (Gupta *et al.*, 1981; Stigter, 1985a; 1985b), fresh leaf water content of maize residues too influenced reflectance (Tanner and Shen, 1990) A 40% fresh leaf water recorded a reflectance of 0.46 in the visible band, while 0.66 in the near IR band. Because the straw alters the net radiative flux at the soil–straw interface, it consequently changes the availability of energy for soil, biological and atmospheric processes (Sharratt and Campbell, 1994). While comparing a midday energy balance between bare soil and mulched soil, Rosenberg *et al.* (1983) found that mulched soil had higher sensible heat but lower net radiation besides latent heat. Interestingly, Wagner-Riddle *et al.* (1996) noted a drastic reduction in the reflectivity of a fully covered surface over a 35-day period due to mulch darkening through natural break-up and decomposition. This decomposition contributes to soil nutrients but slower when on the surface than when incorporated into the soil surface layer (e.g. Mugendi *et al.*, 1994, 1997).

Depending on the previous crop cover, crop residue may be present on the soil as a thin layer, as for example in soybean [*Glycine max* (L.) Merr.], or as a thick layer, as for example in maize. Thick layers encourage short-wave reflectivity, but when relatively open also the transmissivity to solar radiation (Wagner–Riddle *et al.,* 1996), as described by various physical models considering a multilayer approach to describe the extinction of solar radiation

(Ross *et al.,* 1985; Bristow *et al.,* 1986), or even with assumed nil radiation reaching the soil surface (Chung and Horton, 1987; Sui *et al.,* 1992). However, flail-chopped corn residue layers have extinction coefficients much greater than expected for randomly distributed, horizontal, opaque elements (Tanner and Shen, 1990). It was suggested that further refinements of residue transmissivity need to be made (Kopec *et al.,* 1987). As the porous nature of the residue layer is filled with air, it acts as an insulator, as already indicated above also, preventing energy conduction (Olasantan, 1999).With higher albedo of the residue and lower thermal conductivity than the bare soil, it reduces the solar energy reaching the soil and, as a result, reduces temperature increases during warm conditions (Stigter, 1994a) and the reverse during cold periods (Chen *et al.*, 2007).

Soil moisture and temperature together

Among the water-conservation measures, mulching has gained popularity because of its ability to reduce the rate of water loss from both surface and sub-surface soils (Kinama *et al.*, 2005). As we have seen, crop residues maintained upon the soil surface induce a variety of dynamic changes in the atmosphere near the soil surface too. It is a universal truth that straw mulching is an effective measure to conserve soil moisture (Stigter, 2010). However, this influences soil temperature too, which in turn influences crop growth, especially of winter crops. These physical soil protectants influence rate of biological reactions in the soil (Mielke *et al.*, 1986), through, as earlier explained, a change in soil temperature due to insulating material cover such as wood mat and straw (Dionne *et al.,* 1999). Also very little weed growth occurs under the mulch as the mulches prevent penetration of light or exclude certain wavelengths of light that are needed for the weed seedlings to grow (Ossom *et al.*, 2001). As a result, a higher and uniform soil moisture regime is maintained reducing the irrigation frequency or other water use (Ramesh, 2010).

An example of previous maize crop mulch influencing temperatures was described by Chen *et al.* (2007). Although straw mulching is an effective measure to conserve soil moisture, the existence of straw affects soil temperature and in turn crop growth, especially of winter crops. Results of a 5-year field experimentation (2000–2005) at the Luancheng Station on the North China Plain, in a moderately well-drained loamy soil with winter wheat with previous maize crop mulch, showed that the existence of straw on the soil surface reduced the maximum, but increased the minimum diurnal soil temperature. On an average, soil evaporation was down by 21% and 40% over ummulched fields respectively. Mulch reduced soil evaporation from 21 to 40% as compared the control, based on daily measuring of microlysimeters. However, water-use efficiency (WUE) was not improved by mulch, there was yield reduction. Soil-temperature oscillations have been reported by Lal (1974) and Blanco-Canqui and Lal (2009) too. Thus during hot periods, soil temperature was found to reduce due to reduced solar energy reaching the soil, while the reverse due to the reduction in outgoing heat radiation during cold periods (Liu *et al.,* 2014).

Soil thermal properties

Bristow and Abrecht (1989) reported a reduction in soil heat flux density due to residue mulching in wheat under clay loam soils. Evidently, residue retention on the soil manipulates the soil thermal properties near the soil surface (Davies, 1975; Gupta *et al.,* 1981; Othieno, 1982; Stigter, 1984a, b; 1985a, b; 1994a) and not the strata as such as when incorporating the mulch (Mugendi *et al.* 1994; 1997).This happens essentially through increasing resistance of the soil surface to heat (e.g. Stigter, 1968, 1970) and water vapour diffusion (Facelli and Pickett, 1991; cases in Stigter, 2010). It could be widely seen in many parts of various countries that a scattered deposit or retention of unchopped crop residues is used by default after harvest of crops in the tropics for reducing soil temperature and/or improving soil-water conservation (Bussière and Cellier, 1994; Stigter, 2010) without any specific attention to the thickness. This cover effectively protects the surface against evaporation (Singh *et al.,* 2011; cases in Stigter, 2010) by reducing the air movement directly above the surface and increasing isolation from the solar radiation, keeping the soil cool (Awal and Sultana, 2011). However, this coolness is material and season dependent. For example wheat straw mulch raised the soil temperature by 2–3^{o}C (Dayal *et al.*, 1991). Maize straw mulching placed on the soil surface induced a variety of dynamic changes in the microclimate of the soil and the crop. This layer could provide a physical barrier between the soil and atmosphere and consequently improve heat conditions of the soil surface, reduce the eddy thermal diffusivity and the sensible heat flux as well as the latent heat flux (Stigter 1985a, b; Li *et al.,* 2008; cases in Stigter, 2010).

An example of large-scale straw much use in Hebei and Henan Province, China, was presented by Stigter (2010b). An ancient practice for preserving water content and soil moisture, the straw mulching has been more widely used. When farmland is covered by straw, a physical barrier for exchange processes is placed on the surface of the soil, which changes the roughness of the soil/atmosphere boundary layer, as well as the dynamical thermal and moisture properties of the surface layer. Straw mulching forms a layer that interrupts the water and heat exchanges between the atmosphere and the original soil surface. So there is a warming effect in wheat fields mulched with straw in winter. Compared to bare soil, the turbulent exchange coefficient is increased, so is the mulch surface temperature, so the sensible heat flux; however, latent heat flux, that is evaporation, is decreased by the barrier to a large extent. Soil heat flux is significantly reduced due to the insulation properties of the mulch. In other words, with straw mulching, the variation of soil temperature becomes relatively stable, which prevents the winter wheat from freezing. In spring, straw mulching tends to lower the soil temperature, slowing down the rising pace of temperature. This tends to prolong the spiking stage of winter wheat and to produce larger ears on condition that supply of both water and fertilizer are sufficient. Straw is the best mulching material and the appropriate amount is 4,500–6,000 kg/ha. Before mulching, straw should be chopped up to prevent it from pressing the seedlings. The most effective mulching period for winter wheat is from the beginning of winter, which is normally in the second or last decade of December for wheat-growing areas in central and southern Hebei Province. Any earlier mulching may lead to weak seedlings, while delayed mulching may shorten the effective period and its benefits will be compromised. Straw mulching has afferent effects on soil-moisture at different depths in different times. Compared to uncovered fields, larger differences in soil moisture content occur at the depth above 60 cm. Straw mulching can evidently improve the moisture contents of the soil surface layer. If straw mulching is made from the beginning of winter to the wheat jointing stage, the soil moisture of mulched fields will well increase compared to uncovered fields. The soil water content within a 1 m soil layer in straw-mulched wheat fields is in the order of 10 mm higher at the jointing stage of winter wheat than in uncovered fields. Yield increases of generally between 6 and 15% have been measured and water-use efficiency increases of more than 20%, but the latter are generally between 12 and 16% on a multi-year basis. The ecological effects of the practice on farmland include 2 aspects–water and fertilizer. From the perspective of water, as we have seen, the effects are to reduce soil evaporation, hence preserving its soil moisture, and to improve water-use efficiency. In terms of fertilization, straw residues fertilize the soil after long-term physical effects and chemical decomposition, which is a long accumulative process and becomes tangible in the farmlands with multi-year straw mulching.

Modifications in plant physiological functions

In the late-growing season of winter wheat, straw mulching reduced transmittance and reflectance of photosynthetic active radiation (PAR), and therefore the PAR capture ratio increased in winter wheat (Li *et al.*, 2006). Effects of straw mulch on microclimate within the potato (*Solanum tuberosum* L.) crop canopy were dependent on the time of the day, with the air in mulched plots being slightly moister and cooler at night and dryer and warmer during the day and the mulch layer acting as a heat isolator (Döring *et al.,* 2006). Straw mulching promoted transpiration from a wheat crop field by 14–15% over bare conditions (Singh *et al.,* 2011). Saikia *et al.* (2014) found an appreciable enhancement in PAR interception in mustard cultivars 'NPJ 113' and 'P 28' to the tune of more than 100% over unmulched control in Meghalaya, India, at 40 days after sowing. The daily average photosynthetic absorption of wheat straw mulched rainfed peach (*Prunus persica* L.) showed an improvement from 11.4 to 12.2 μmol/m^2/s (Wang *et al.,* 2015).

Although it is unclear in which situations mulch can facilitate or inhibit plant recruitment, straw mulch and seed-containing hay are for example convenient methods to expedite prairie reclamation. Both techniques are effective and practical for practitioners even for large-scale reclamation endeavours (Török *et al.,* 2011; Desserud and Naeth, 2013). While most of the success of native hay mulching is ascribed to allocation of viable seeds to a site where the soil seed bank was already depleted (Donath *et al.,* 2007; Coiffait-Gombault *et al.,* 2010; Kiehl *et al.,* 2010), the physical inhibitory effects at different transfer rates should be understood to better develop reclamation practices.

CONCLUSION

Residue mulch kept on or applied to the soil modifies crop microclimate above and below soil surface and within and above the mulch in numerous ways. It may be positive for the seedbed by preventing water loss from the soil surface, yet thick layers may prevent germination of seeds that positively respond to light and to temperature fluctuations. Manipulating residue or soil colour is a means of altering the microclimate in agricultural production systems. Mulch acts as a physical barrier for exchange processes on the surface of the soil, which changes the roughness of the soil/ atmosphere boundary layer, as well as the dynamical thermal and moisture properties of the surface layer. This straw layer interrupts the water and heat exchanges between the atmosphere and the original soil surface and is a clear example of microclimate management and manipulation as that has been developed traditionally but also more contemporarily. Mulch is used to manage and manipulate radiation, heat, moisture and mechanical impacts in various forms by influencing exchange processes, most often positively, as well as by mitigating hazardous phenomena due to these processes. Mulching is shown to be particularly protective in various ways and although often applied in small-scale agriculture, also large scale use. The residue mulch kept on or applied to the soil is still worth a full understanding to generate its proper use under scores of different conditions.

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