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Role of Mulching and Nitrogen Management in Crop Production

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Abstract
Sustainable crop production techniques should be adopted to reduce environmental degradation and resource management. Mulching is the practice of spreading or distributing any material on soil surface which helps in solarising the soil, reduces evaporative loss of moisture, inhibiting emergence of weed, disturbing life cycle of certain pathogen and insects and prevent runoff and loss of soil. Materials used for mulching are plastic sheet, gravel, sand, basaltic tephra, rocks, crop residues, vine residues, paper mulch, cellulose etc. Plastic mulches are more effective than organic mulches. Evaporative loss of soil moisture is reduced to a greater extent by mulching as it covers the bare soil to prevent direct exposure to solar energy and conserves the water within the soil. Nitrogen, being an essential plant nutrient and prone to leaching, denitrification, volatilization, runoff and other losses requires proper management strategy. Mulching reduces the frequency of irrigation and maintains the soil temperature due to which leaching loss and ammonia volatilization is controlled respectively. Split application of nitrogen is another management strategy to prevent losses of nitrogen that also provide higher yield as it meets the crop demand at different growth stages.

Keywords: Evaporation, Mulching, Nitrogen Use Efficiency

Introduction
According to United Nations (2019), world population is forecasted to reach 9.7 billion in 2050, which projected around 34% increase from the current population. The present day challenges in agricultural sector derives from natural (FAO, 2015) and anthropogenic causes (Khan *et al*., 2009). Unpredictable events arising from climatic variations (Kang *et al*., 2009), exploitation and depletion of natural resources, environmental pollution and industrialization has brought a decline to agricultural production. Sustainable crop production is necessity of the time to achieve the food security and healthy environment for the future generation.

Water is an inevitable natural resource and limiting factor that determines the potential crop yield. The FAO report prepared for G20 presidency of Germany, (2017) point out the usage of water by agriculture as 70% of global water use by all sectors.

Fertilizers augment the crop yield but the same in excess without studying the applied environment could make adverse impact through residual properties, acidification, pollution etc. Expense for the fertilizer has remarkable role in B:C ratio. Any measure to abate the recommended rate of nutrients is adoptable if it provide same yield as recommended dose of fertilizers (RDF). The uneconomical part is the loss of applied N fertilizer by means of leaching, volatilization, denitrification which can be avoided by split application of nitrogen.

Mulching: Innovative, environment friendly and economically feasible technology
Selection of mulching material is of prime importance as it has influence on yield. The purpose of mulching determines the selection of mulching material that included transparent plastic sheet, black colour sheet and reflective type with colours white and silver (Patil *et al*., 2013). Black polythene mulch aids in weed control, moisture storage in soil and obstruct the radiation from going outside to some extent while cooling effect is provided for the root zone by silver sheets and elevated soil temperature is characterized by transparent sheet. Degradability based classification comprised of photodegradable mulch sheets that

undergoes sunlight destruction and bio degradable with temporal degradation. Tomato plants with taller height and few axilliary shoots observed in plots mulched with black polythene with comparison to white polythene mulch (Decoteau *et al*., 1988).

An experiment conducted with rice straw and plastic mulch in baby corn by Mahajan *et al*. (2007) showed that about 19% increase in yield obtained by using plastic mulch over rice straw and 77% over unmulched treatment. Yield attributes of baby corn were higher for mulched treatments than unmulched in sole crop of baby corn and mustard (Sarkar *et al*., 2011).

Competition due to weed infestation reduces the yield of the crop drastically during early stages. Application of mulch on the soil surface nearby plants do not give space for weeds to grow. Application of polythene increases soil temperature which may kill underground propagules of weed and create a hindrance to emerge out of the soil. Ramakrishna *et al*. (2006) studied the effect of rice straw, plastic and chemical mulch on yield of groundnut and found that plastic and straw mulched plots were most effective in weed control than chemically treated plots .

Mulching is an effective technique to bring down evaporative loss (Zribi *et al*., 2015) but degree of efficiency relies on type of mulching material as well as meteorological conditions. Compared to bare soil, organic mulch applied soil has low water depletion rate as it act as barrier for evaporation and changes microclimate (Sarkar *et al*., 2007). Impervious materials like plastic sheets laid on soil minimize evaporative loss of water and prevents the entry of water into the root zone while porous materials help in the entry of water into soil. Mulching in irrigated wheat, bring down soil evaporation by 35 - 40 mm but the water was not conserved because transpiration increased in crop with less transpiration efficiency (Singh *et al*., 2011).

Residue management is necessary to abate air pollution with improved benefits. Chen *et al*., 2007 conducted an experiment in winter wheat cultivated by incorporating the residues from previously grown maize as well as spreading on the surface as mulch. It has been concluded that straw mulch at 3000 kg/ha reduced soil evaporation by 21% while mulching at 6000 kg/ha gave a 40% reduction as compared to straw incorporated treatments. Evaporation is found to be suppressed by application of sand mulch and the effectiveness depends on thickness of the applied layer and it's texture. Mulch layer of 6 cm thickness and coarse texture were more effective evaporation suppressor than fine textured sand mulch (Modaihsh *et al*., 1985).

Among the inorganic mulches like sand and rocks, basaltic tephra is most effective in reducing soil evaporation in arid regions which directly related to thickness of the mulch and inversely related to grain size (Diaz *et al*., 2005). Gravel mulch abates soil surface evaporation in arid and semi arid regions with balancing the soil moisture content within the soil. Effectiveness of the gravel mulch has negative correlation with the gravel size as ratio between surface soil evaporation and atmospheric evaporation increase with increasing gravel size (Yuan *et al*., 2009). So, smaller the size of the inorganic mulches like sand, rocks, gravels and tephra, greater will be the efficiency of those particles in reducing soil surface evaporation. The comparison of sand or gravel mulched and non – mulched field of watermelon observed that ratio between evaporation to evapotranspiraion obtained were 17.8% - 25% and 40% respectively (Xie *et al*., 2006). Gravel mulching alone on the field reduced the evaporation by 16.9 – 26.3 mm but when plastic mulch spread over the gravel mulch, soil evaporation reduced by 78.0 – 93.7 mm. Plastic mulch in maize grown plots only allowed 20 mm water to loss through evaporation (Li et al., 2013). Straw mulch reduced evaporation in freeze – thaw period and varies with thickness and coverage of mulch. Under the freeze – thaw period, thin straw mulch layer (1cm) and thick straw mulch layer (2cm) with full coverage and half coverage reduced the water loss via soil evaporation by 32.1 %, 38.4% and 28.7% respectively (Chen *et al*., 2019).

Nitrogen plays an inevitable part in the physiological process (Leghari *et al*., 2016) in a plant as a component of proteins, chlorophyll, genetic materials and thus provides the building blocks for plant growth. The optimum application of N is prescribed as the excess dose could make adverse toxic effects in plants and soil with economic losses while inadequate application does not satisfy the need of the plant and produce deficiency disorders in plants. A reduction happens in the quantum yield of PSII due to the nitrogen deficient condition in wheat and maize (Lu et al., 2001). Increased nitrogen levels from 90 - 120 kg ha^{-1} (Golada *et al*., 2013) significantly enhanced both the vegetative as well as reproductive growths of baby corn.

Nitrogen management through mulching

Economic sustainability of cropping system is obtained by efficient use of all resources, particularly limited resources. Nitrogen, a limited nutrient in most parts of the agricultural soil needs an efficient management due to its dynamic nature and proneness to loss from soil – plant system (Fageria and Baligar, 2005). N recovery in plants is low as less than 50% because applied nitrogen fertilizer is susceptible to leaching, volatilization, runoff and denitrification and low recovery of N creates economic losses and environmental pollution.

As mulching conserves moisture, the need of frequent irrigation is dissolved thus it reduces leaching losses of nitrogen with irrigation water and reduces volatilization as ammonia which is stimulated by temperature rise.

Paddy straw mulch and citronella distillation waste mulching in Japanese mint made an increase of 18% and 25% in nitrogen uptake respectively in comparison to an unmulched plots (Patra *et al*., 1993). Organic mulch like paddy straw applied in geranium provided with 160 kg N/ha has economic benefits than other treatments (Ram *et al*., 2003).

No mulch, black polythene mulch and cellulose mulch (biodegradable) were compared in *Capsicum annum* L. and inferred that leaching of NO_3^- - N is efficiently controlled by black polythene mulch, which additionally provided high yield (Romic *et al*., 2002). Vertical distribution of soil nitrate-N is influenced by mulching (Wang and Xing, 2016; Xiukang *et al*., 2015). An increase in soil nitrate-N content observed in 0 – 40 cm of plastic mulched maize field with basal and top dressing split application (Wang and Xing, 2016). Gravel mulching and plastic mulching enhanced N uptake in maize as well as NUE through maintenance of soil moisture and N conditions (Liu *et al*., 2015). Qin *et al*., 2015 conducted a meta analysis in wheat and maize over 19 countries, mulched with plastic and straw and observed a 20% increase in water use efficiency, yield and NUE for

wheat while a 60% increase observed for maize in yield, WUE and NUE. Surface soil layer covered with maize straw mulch in combination with no-tillage practice enhances temperature buffering effect and moisture conservation which results in high NUE and WUE in dry period. This have the benefits in releasing plant available soil N as well as Olsen Phosphorus through increased concentration of soil urease and neutral phosphate (Yang *et al*., 2020). Nitrogen uptake efficiency is enhanced with response to vigorous root growth benefited from high plant available nitrogen.

Conclusion

Mulching is a sustainable crop production technology which have the benefits of water conservation, evaporation control, hindrance to life cycle of weeds and insects as well as nitrogen management. Bare soil is prone to evaporative loss of soil moisture. Any material like gravel, sand, tephra, plastic sheet, crop residues, cellulose mulch, pine bark etc spread over the soil can reduce the evaporative loss and stores the water in soil layers for plant use. Water loss can be prevented by thick mulches with low individual grain sizes for inorganic mulches like rock, sand, tephra and gravel. Nitrogen fertilizer is susceptible to leaching, volatilization, runoff and denitrification. Since mulching conserve water, frequent irrigation can be avoided. This reduces the leaching of nitrogen fertilizers. As well as mulching regulates soil temperature which reduces volatilization losses of ammonia. Thus mulching assist in nitrogen management.

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