

SUSTAINABLE COTTON PRODUCTION UNDER CLCuD THREAT

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The incidence of Cotton Leaf Curl Disease (CLCuD) and low crop stand are major impediments to sustainable cotton production in Pakistan. Early sowing provides protection against CLCuD but causes low seed germination. Early cotton planting overlaps with wheat harvesting, thus causing conflict with Wheat-Cotton-Wheat cropping pattern. To address these problems and suggest improvements, a series of field experiments was conducted to optimize cotton planting technology. Three sowing methods viz., transplanting cotton nursery in May, direct seeding in March, and direct seeding in May were compared for physiological indices, CLCuD incident and yield of seed cotton. For the production of seedlings, four nursery media were evaluated for their efficiency in terms of germination percentage, seedling survival, and convalescent period. On the basis of these parameters, SSM (Soil+Sand+Manure) media produced better seedlings. The early sown (transplanted) cotton gave good escape from CLCuD. The maximum incidence was observed in May sowing (22.2%) while the severity was maximum in the month of August. Maximum seed cotton yield was recorded in March sown-transplanted cotton. Income generated from March sowing was more than transplanting due to labor cost in transplanted cotton. The income from transplanted cotton was 60% more than the May sowing, on account of better production due to improved crop stand, number of growing days and escape from CLCuD. Therefore, early planting of cotton through seedlings transplantation is suggested to improve cotton production through better crop stand and escape from CLCuD in a cotton-wheat production cropping system.

Keywords: cropping system, cotton transplanting, cost of production, sowing media

Abbreviations: SSM: Soil + Sand + Manure; SM: Soil + Manure; SS: Soil + Sand

INTRODUCTION

The Cotton Leaf Curl Disease (CLCuD) and low crop stand are among the major problems to cotton production in Pakistan. To avoid the CLCuD problem, early sowing is started in March even few farmers plant cotton in February instead of May-June. Cotton is 150 days cash crop, but due to early sowing, it has become high input 300 days crop and consequently, double cropping in wheat-cotton-wheat system is affected. The low crop stand due to poor germination is another inherent problem to cotton production. In Southern Punjab, Wheat-Cotton-Wheat cropping pattern is commonly followed. Cotton contributes about 1 % share in GDP and has 5.5% share in agricultural value added commodities (Anonymous, 2016-17). Changing scenario in agriculture due to the changing environmental conditions, a new cropping pattern is developed after the adoption of the insect-resistant *Bt* cotton. Now, it is planted early, which overlaps with wheat crop and thus affecting wheat cultivation and production. Cotton grown after wheat following wheat-cotton cropping pattern, poses many problems including: (1) the cotton production is instable and the quality declines, (2) the planting density of cotton is thin, less than 23000 plants/acres and (3) sowing too late affects germination and plant growth and

development (Bauer *et al.*, 1998; Forrester, 2008). The population of whitefly during dry and hot conditions increases and promotes spread of CLCuD at the early growth stage of cotton, which results in stunted growth and is the major threat to cotton production (Mirza *et al.*, 1994; Khan and Rashid, 1996; Khan and Ilyas, 1998; Raza *et al.*, 2016).

It is observed that late planting in May and during June increases the incidence of CLCuD up to 20% as compared with early sowings (Khan and Khan, 1995). Consequently, cotton has become high input 300-day crop and wheat sowing no longer remains possible (Forrester, 2008). This practice requires compromising wheat production, which is a staple food in Pakistan, hence, possibly posing threats to food security.

Sowing time is not only important for disease and insect pest control, but also important for managing cotton crop stand and its yield (Kamel *et al.*, 1991). It is recommended that plant population should be maintained to minimize yield losses (Hall and Ziska, 2000). Early sowing of cotton in February-March has low germination due to low soil and air temperatures and does not fit with double cropping system of wheat-cotton-wheat pattern. First five days are very important for cotton seed germination and if seed does not receive favorable conditions, it shows delayed emergence and low

germination, which consequently results in poor crop stands, yield loss and high risk of seedling diseases (Boman and Lemon, 2005). For better germination, the soil temperature should be at least 65° F (20°C). Cotton seed germination can be sporadic at soil and air temperatures less than 58°F (15°C) (Boman and Lemon, 2005).

To solve these problems, scientist and farmers are looking for alternate planting methods for better crop stand. Planting of healthy seedlings to raise the cotton crop could be a possibility. In this system, cotton seedlings are raised by covering with plastic sheets during the early season and transplanted to open fields (Dong *et al.*, 2004, 2005). This practice is usually applied for planting rice, tobacco and vegetables (tomatoes, peppers, etc.). Transplanting maize, potatoes and sugar beets gave striking results in Bavaria in Canada. (Christidis, 1962). Transplanting is mostly practiced where crop seeds are small or delicate, the growing season is relatively short, or for obtaining higher yield and earlier crops. Transplanting of cotton seedling found to be successful in increasing the yield and also improve crop establishment by avoiding harmful environmental effects before transplanting (Kamel *et al.*, 1994). Seedling transplanting also extend the duration of growth and development in comparison with direct sowing (Radwan and Abd-El-Malak, 1995; Dong *et al.*, 2005). Cotton transplanting increased farmers' income, and provided advantages of grain and cotton production in China (Zhu and Gao, 1993). Many other countries are getting benefits from cotton seedling transplanting and have even mechanized transplanting (Sherif *et al.*, 1995; Jawaheri, 1999; El-Sahrigiet *al.*, 2001; Greer *et al.*, 2003; Karve, 2003). However, growing cotton nursery is still a challenge, many experts and producers have tested a variety of methods, such as naked-root transplanting techniques, soil-less seedlings, and micro-bowl seedlings. In China, nursery pots are most commonly used for cotton nursery (Sun and Wang, 1996; Yu *et al.*, 2000).

The present study was designed to assess the benefits of transplanting cotton on yield by maintaining plant population and diseases management, especially CLCuD. The findings of this study will help farmers in profitable early sowing of cotton in wheat-cotton sowing system by transplanting two months old nursery to establish proper crop stand. It will also help to escape from CLCuD and maintaining the wheat-cotton cropping rotation.

MATERIALS AND METHODS

The seed of an elite cotton variety MNH-886 was obtained from Cotton Research Institute, Ayub Agriculture Research Institute, Faisalabad. Germination test was conducted in four replications of 100 seeds with paper towel methods, as described by ISTA (International Seed Testing Association, 1999). The experiment was divided into two parts. In the first step, cotton was grown in polythene bags (5×7 cm) in

Completely Randomized Design (CRD) and at the same time it was sown in field in Randomized Complete Block Design (RCBD) in the month of March. In second step, cotton grown in polythene bag, was transplanted in field and at the same time it was sown with delinted seed in field in Randomized Complete Block Design (RCBD) in the month of May during the year 2013-2014 (Latitude = 31°- 26' N, Longitude = 73°- 06' E, Altitude = 184.4m). The row to row and plant to plant distances were 75 cm and of 25 cm, respectively.

To get healthy seedling four types of media were evaluated, seedling from two media were used in transplanting experiment, which were transferred to field in RCBD design. Media was prepared and used with ratio of *i*) 1:1 soil: sand *ii*) 2:1:1 soil: sand: manure *iii*) 3:1 sand: manure *iv*) 3:1 soil: manure.

Variances and covariances for the seedlings were estimated for seed germination (%), seedling survival (%), dry matter content (%), convalescent period (No. of days). For field planting, survival (%), seed cotton yield (kg/acre), cotton leaf curl virus incidences were computed following steel *et al.* (1997). The results were analyzed according to the analysis of variance for the CRD in case of polythene seedling and RCBD in case of field sowing. The LSD was computed at 5% significance level for comparing the treatment differences.

The costs of variable inputs such as fertilizer, seed, insecticide, weeding, harvesting, picking, and fixed expenditures involved for land preparation and sowing were computed for different sowing systems using the costs of inputs. Net profit from each cropping system was computed by subtracting the operational costs (*i.e.* variable costs and fixed costs) from the gross value of the produce. Prices as realized at the time of harvest of crops were used in estimating the gross value of the produce.

RESULTS

Best suited media for cotton nursery: Medium was assessed through seedling emergence, seedling survival, dry matter content and convalescent period. Sand+Soil+Manure media was found most suitable as cotton seedling showed better emergence, survival and dry matter contents. The maximum emergence (96.6%) was recorded by cotton seed sown in Soil+Sand+Manure (SSM) which is 34.3% and 23.3% more than Soil+Sand (SS) and Sand+Manure (SM), respectively (Fig. 1). The minimum emergence (62.3%) was observed in Soil+Sand media followed by Sand+Manure (73.3%). Similarly, for seedling survival rate the maximum numbers of seedling (98.6%) were survived in Soil+Sand+Manure (Fig. 2). The minimum survival (55.6%) was observed in Soil+Sand media followed by Sand+Manure (63.3%). The results of our experiments showed that manure may convey greater benefit to seeds and seedlings than those that have without manure. In case of dry matter contents, the maximum value of dry matter contents (35.9%) was recorded for cotton

seed sown in SSM (Fig. 3). While, seedling dry matter contents in polythene bags having Soil+Manure as a growing media ranked second (30.7%).

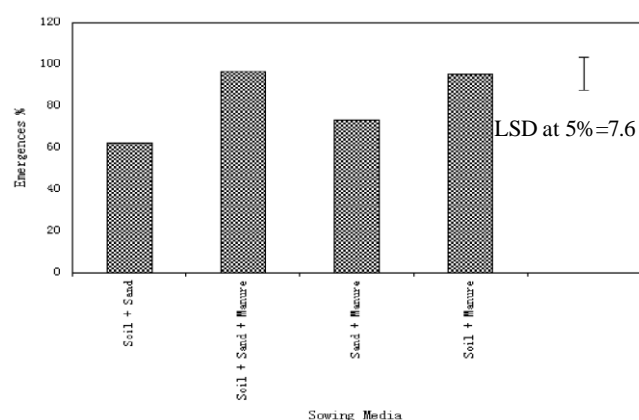


Figure 1. Seedling emergence % in different sowing media.

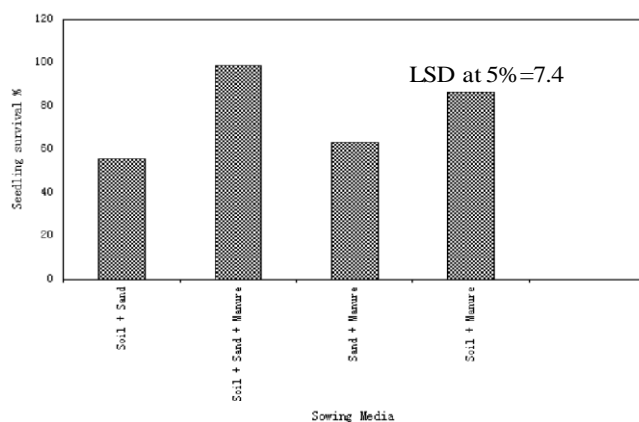


Figure 2. Seedling Survival % in different sowing media.

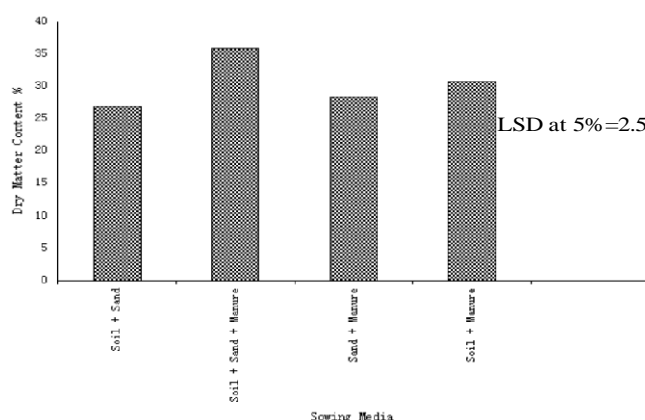


Figure 3. Seedling dry matter contents (%) in different sowing media

The minimum dry matter contents (26.9%) was observed in Soil+Sand media. In general, there is a convalescent period (number of days taken in adapting to a new environment when cotton seedlings are transplanted into the field, due to water loss of seedlings and some root death (Xu *et al.*, 2007). Seedling from Soil+Sand+Manure media showed minimum number of day (convalescent period) to overcome the transplanting stress (7 days) while Soil+Sand took more than 8 days to recover from transplanting stress (Fig. 4).

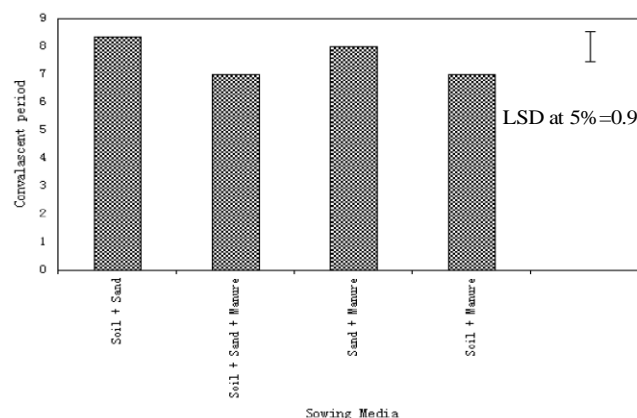


Figure 4. Convalescent period in different sowing media

Comparison of transplanting and direct sowing:

Emergence %: Emergence of cotton seedling was evaluated at two different sowing times, 1st in March and 2nd in May. The maximum emergence (79%) was recorded in May sowing, which is 28% more than the early sowing (Fig. 5). While, seedling emergence in March sowing was lower (51%). the results of present study showed that seedling emergence in the month of May was better compare to in the month of March.

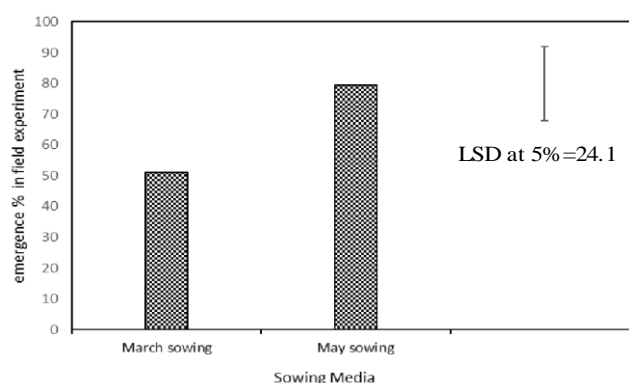


Figure 5. Seedling emergence (%) in different sowing dates

Crop-stand: Plant population per unit area is a critical component in achieving good yields. The plant stand of cotton in different sowing dates and transplanting systems was noted

near harvest. Sowing dates significantly influenced crop stand of cotton. In both transplanting treatments, cotton crop stand was good. Maximum crop stand was observed in transplanted cotton with nursery media of Soil+Sand+Manure which was above 99% (Fig. 6). This is due to the high survival rate of seedlings and low transplanting stress in this media. Low crop stand was observed in direct sowing in both seasons in March and May compare to transplanting. In cotton sowing 20,000 plants population is consider as standard. In SSM media, crop stand was 19,910 which had 3083 and 3810 number of plants more than March and May sowing. Gap filling in March and May sowing was done 3 and 2 time respectively even then recommended crop stand was not attain. These results demonstrated that transplanting cotton greatly help to desired plant population in field, which greatly help to increase yield. This increase in plant population may be due to removal of different stress that cotton face at emergence time. (low temperature, water stress and soil borne diseases) (Vos, 1995; Leskovar and Vavrina, 1999; Dong *et al.*, 2010)

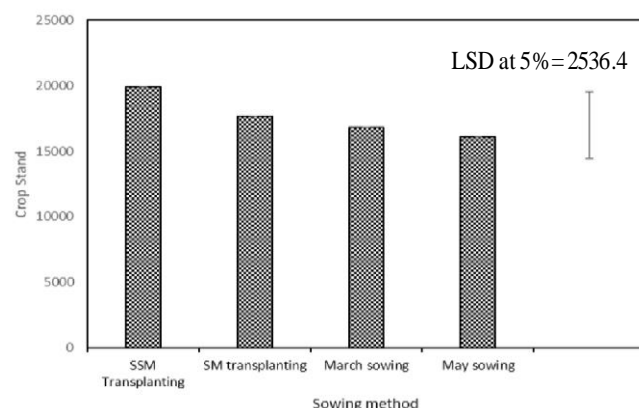


Figure 6. Crop stand (No of plants) in different sowing dates

CLCuD incidences: Environmental conditions and age of plant is considered critical in CLCuD incidence. The CLCuD incidence in cotton in different sowing methods was noted at 10 days interval and mean value was calculated. The results revealed that CLCuD incidence was influenced by sowing dates (Fig.7). The plant population achieved through transplanting and March sowing was significantly different from May sowing. Both the transplanted cotton and early sowing gave good escape from CLCuD. Among the

transplanted cotton SSM had comparatively low incident of CLCuD. The maximum CLCuD incidence was observed in May sowing (22.2%) (Fig.7).

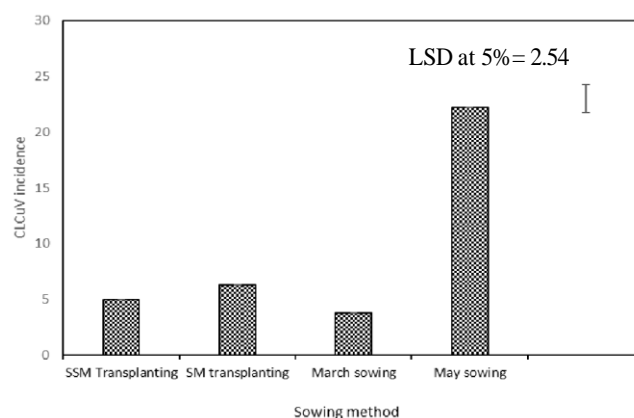


Figure 7. CLCuD incidence (%) in different sowing dates

Crop Yield: Results showed that SSM transplanting produced significantly ($P \leq 0.05$) more seed cotton yield than May sowing. It is evident from the results that the SSM transplanting tended to produce more seed cotton yield than March sowing but the differences between them were found to be non-significant (Fig. 8). Thus, the highest yield was produced with the SSM transplanting (1920 kg/acre) and the lowest seed cotton yield was observed with May (1146 kg/acre) sowing in all treatments. Increase in yield is due to the prolong season and high crop stand in transplanted cotton.

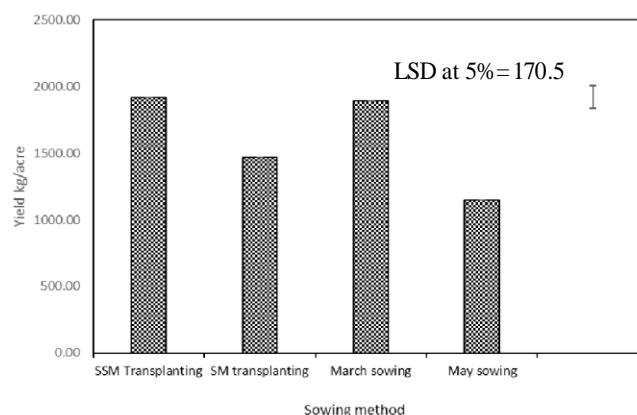


Figure 8. Seed cotton yield acer^{-1} sowing methods

Table 1. Input, output and net income in cotton production with SSM transplanting, early and late system.

Sowing System	Seed cotton yield (mound/acre)	Input values (Rs.)	Output values (Rs.)	Income (Rs.)
SSM Transplanting	48.0	86015	144000.0	57985
March Direct Sowing	47.3	66065	141997.5	75932
May Direct Sowing	28.7	57065	86002.5	28937

Cotton seed price was 3000 rupees /40 kg in 2013. Material input includes transplanting bags, fertilizer and other fees. It costs 0.75 rupee per plastic nursery pot.

Cost benefit ratio: Budget analysis revealed the highest gross return was in direct early sowing cotton (75932 rupees/acre) followed by transplanting (57985 rupees/acre). (Table 1). In transplanting cotton cost of production is high due to more labour cost for transplanting and for removing the plastic shells but this cost could be decreased by developing new transplanting methods with cotton transplanter. In transplanting cotton plants remain free from weeds problem which saves initial cost on weedicides used.

DISCUSSION

Cotton is currently the leading fiber crop worldwide and is grown commercially in the temperate and tropical region of more than 50 countries (Smith, 1999). Despite the fact that cotton breeders all over the world have been making continuous efforts for the improvement of yield and quality of cotton crop, yet these efforts have not proved to be good enough to achieve the yield average to a level of other cotton growing countries of the world. Apart from other exigencies, one of the most conspicuous reasons for low productivity could be low crop stand and CLCuD of cotton plants. The breakthrough in higher yield and cotton production may be achieved by the exploitation of new techniques. Transplanting two months old cotton nursery, not only allowed earlier sowing, but also greatly helps in desired plant population. In our study maximum plant stand was found in SSM transplanting which was similar to the results found by Dong *et al.* (2007)

There were significant differences in performance amongst cotton seedlings grown in different media. Vegetative growth and development depended on to the capacity of the media for retention, maintenance of nutrients and water. Possibly different types of media held moisture and nutrients in varying amounts for use by the growing plants, thus, affecting the growth and development of the seedlings, studied differently. The emergence rates in Soil+Sand+Manure (SSM) and Soil+Manure (SM) media treatments were significantly higher than Soil+Sand (SS) and Sand+Manure (SM). These results may be due to sandy loam soil with better availability of soil supplements, necessary to enhance seed germination in cotton. There is a convalescent period in adapting to a new environment when cotton seedlings are transplanted into the field, due to water loss of seedlings and some root death (Xu *et al.*, 2007). Factors affecting convalescence time include age and seedling quality, transplanting technology and environmental conditions during transplanting (Xu *et al.*, 2007). Shorter convalescence period of cotton seedlings in SSM media may be due to many reasons as. Firstly, seedling roots in SSM form more developed root system. Secondly, at the time of transplanting where sand proportion is more root damage increased greatly, but in SSM, proportion of sand is good giving compact structure which is ease to transfer with lesser root damage.

Better seedling height in SSM media may be due to the better root development in sandy soil and more availability of the nutrients to emerging seedling. In this study, the total dry matter of SSM was greater than all other provide better cotton root production and shoot growth. These results found are similar to those found by Zhang *et al.* (2012). Transplanting by using SSM are significantly enhance seedlings dry matter contents compared with SM. Due to cotton indeterminate growth, transplanting may have a significant impact on dry weight, roots length, and vegetative and help in reproductive parts development (Bange and Milroy, 2007; Read *et al.*, 2006; Akram-Ghaderi and Soltani, 2007; Liu *et al.*, 2010).

One of the most important agronomic considerations for grower is to ensure optimum yield and quality of the crop. It is evident from the previous findings that early sown crop has higher number of bolls per plant compared to late sowing (Ali *et al.*, 2009). The early sowing and transplanting provided escape from CLCuD. It was observed that late planting at the end of May and June increase the rate of infection by CLCuD up to 20%, depending on variety, plant density and temperature conditions, compared with early sowings (Khan and Khan, 1995). Both the early sown crop and transplanting cotton protect the plants from high level of CLCuD attack, as shown previously by Tahir and Mehmood, (2005). The economic analysis of any agronomic practice is essential from farmer's point of view, as they are often interested in benefits and costs of a certain practice and also like to know about risks involved in adopting new technologies. Cultivation of cotton is labor-intensive as compared to wheat, corn, and other field crops, with higher inputs as well as higher outputs. The use of transplanting required more cost in start but it could easily be compensated by yield. Output per unit area was higher for transplanting cotton then the direct sowing in May. However, there was a need to decrease other costs such as nutrients, pot and related materials, transplanting nursery management and labor. It is noteworthy that higher net income for the transplanting system was mainly due to significantly increased yields and increase in crop stand and protection from CLCuD.

Conclusion: Present study concludes that early sowing in March and transplanting seedlings in May will give good escape from CLCuD and provide more economic gains than late sowing. But, sowing early in March is cheaper than transplanting because of labor cost while crop stand was better in case of transplanting.

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