SEED COTTON YIELD AND WATER USE EFFICIENCY OF COTTON (*Gossypium hirsutum* L.) SOWN IN DIFFERENT PLANTING METHODS

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Three experiments were conducted to ascertain the yield performance and water use efficiency of cotton (*Gossypium hirsutum* L.) sown in different planting methods during the year 2005, at three different locations in cotton zone of Punjab (Pakistan) province in case of different planting methods The planting methods were, flat planting and no earthing up, flat planting and earthing up after 1st irrigation (35 days after planting) , flat planting and alternate row earthing up after 1st irrigation, flat planting in 112.5/37.5 cm apart paired rows and earthing up after 1st irrigation, ridge planting and bed planting. Cotton crop obtained a maximum benefit from the available water at all three locations in flat planting with alternate row earthing up method by giving a maximum water use efficiency of 5.63 kg ha^{-1} $mm^{-1}$and maximum seed cotton yield of 2991 kg ha^{-1}.
Keywords: Cotton, water use efficiency, planting methods

INTRODUCTION

Pakistan is predominantly an agricultural country and prosperity of the peoples depends largely upon the successful cultivation of crops such as wheat, cotton, rice, sugarcane and maize. Among these cotton is a crop of high national importance because it earns substantial foreign exchange (more than 60%) through the export of raw cotton, yarn and finished products (Anonymous, 2005). In addition cotton crop also provides livelihood to millions of people that are engaged in the textile industry directly or indirectly.

Realizing the immense importance of cotton plant in building the economy of Pakistan, it has always been the objective of extensive research to improve the yield potential of the crops under local environmental conditions and better utilization of the source available for successful crop production. Successful production of cotton crop totally depends upon the availability of the irrigation water either it comes from canal or tube well. Irrigated agriculture is facing growing competition for low cost, high quality water (Howell, 2001). High quality irrigation water is being deficit day by day and the world is looking for water saving agriculture, it refers to farming practices, able to take full advantage of the available irrigation facilities (Xi. Ping Deng *et al*., 2004). Water saving agriculture intends to raise the water utilization rate and water use efficiency that is to achieve a high economic yield on irrigated farm.

Water use efficiency is a potential selection criterion for improving yield under water stress and it evaluates the way and depth of water application, whether it was used at the best level by the crop. Usually cotton crop uses less water per hectare than other agricultural industry but exception of horticulture (Hearn, 2000). Water use efficiency is not simply water saving irrigation but it is comprehensive exercise using every possible water saving measure in whole farm production, including the full use of natural precipitation as well as the efficient management of an irrigation network through a suitable planting method. Planting methods are an important factor which affects crop growth development and finally the crop yield. Reducing the row spacing resulted in an increased light interception, growth rate, total biomass production, and water use efficiency (Staggenborg *et al*. 1992). Better water use efficiency can be achieved through the adoption of best irrigation management practices (Goyne and McIntyre, 2001). According to McAlavy (2004), adoption of subsurface irrigation on small acreage can increase cotton yield, water use efficiency and return per acre.

Adoption of appropriate planting method and water management for successful crop production are the most critical problems specially in cotton growing areas of Pakistan, where the underground water is almost brackish and source of irrigation is only the canal water, which is being scarce day by day and it is a dire need to utilize every inch of available water in an efficient way.

The present study was, therefore undertaken to evaluate the most suitable method of planting cotton to increase water use efficiency and seed cotton yield per unit of land.

MATERIALS AND METHODS

Three experiments were conducted during the year, 2005 at three different locations; 1, Agronomic Research Station, Bahawalpur 2, Farmers field in District Bahawalnagar 3, Farmers field at Ahmed Pur East. Two cotton varieties, BH-160 and CIM-506 were

planted in 2nd fortnight of May, under six different planting methods viz., flat planting and no earthing up (P_1), flat planting and every row earthing up after 1st irrigation (P_2), flat planting and alternate row earthing up after 1st irrigation (P_3), flat planting in 112.5/37.5 cm apart paired rows and every row earthing up after 1st irrigation (P_4), ridge planting (P_5) and bed planting (P_6). The trial was laid out in split plot by randomizing planting methods in split and varieties in main plots with a plot size 4.5 x 15m. 1st irrigation was applied to P_1, P_2, P_3 and P_4 at 35 days after planting and earthing up was done according to the treatments; P_5 and P_6 were irrigated just after the planting. Subsequent irrigations were applied according to the need of crop and planting methods. Each time a measured quantity of irrigation water was applied with the help of cut throat flume using the formula Qt = Ad or t = Ad/Q and each irrigation was 7.5 cm in depth. Seed cotton yield data were recorded and water use efficiency was calculated using the formula given by Viets (1962)

$$WUE = \frac{cropyield(economicyield)}{waterused(I + R)toproducetheyield}$$

I = Irrigation
R = Rainfall

Data were analyzed statistically by using Fisher's analysis of variance techniques and least significant difference (LSD) at 5% probability was applied to compare the differences among treatment means. (Steel *et al*., 1997).

RESULTS AND DISCUSSION

Seed cotton yield parameters

It is evident from Table1 that planting methods had non-significant effect on plant population, sympodial branches, boll weight and seed index, however, number of opened bolls plant^{-1} were affected significantly by planting methods. Maximum number of opened bolls plant^{-1} (37.60) were recorded in P3, followed by P5 and P6 (37.00 opened bolls plant^{-1}). Maximum number of opened bolls plant^{-1} in P3, P5 and P6 was, most probably due to better utilization of the available water. Minimum value (35.10 opened bolls plant^{-1}) was observed in flat planting method with no earthing-up (P1).

Table 2 an 3 showed that plant methods had not any significant effect on plant population m^{-2}, sympodial branches plant^{-1}, number of opened bolls plant^{-1}, boll weight and seed index.

Seed cotton yield and water use efficiency

Seed cotton yield and water use efficiency in relation to different planting methods (Table-4) revealed that the crop obtained a maximum benefit from the water available in flat planting with alternate row earthing up (P_3) at location No.1, producing maximum seed cotton yield of 2991 kg ha^{-1}, followed by P2 (2911.5 kg ha^{-1}). However, it was statistically at par with P3. The lowest seed cotton yield (2714 kg ha^{-1}) was obtained in flat planting and no earthing up(P1). Water use efficiency was significantly influenced by planting methods (Table 4). Maximum water use efficiency was observed (5.63 kg ha^{-1} mm^{-1}) in flat planting with alternate row earthing up (P3) followed by P4 (5.19 kg ha^{-1} mm^{-1}) while minimum value was obtained in flat planting and no earthing up (P1) (4.17 kg ha^{-1} mm^{-1}).

Table 5 predicted that planting methods had non-significant influence on seed cotton yield while water use was affected significantly by planting methods. Highest water use efficiency (4.66 and 4.46 kg ha^{-1} mm^{-1}) were observed in P3 and P4, respectively while lowest value of water use efficiency was observed in P1 (3.64 kg ha^{-1} mm^{-1}).

Data regarding seed cotton yield and water use efficiency in Table 6 exhibited that planting methods had non-significant effect on seed cotton yield, yet the maximum seed cotton yield (2746 kg ha^{-1}) were obtained in P3 by using minimum quantity of water (517 mm), followed by P2 (2738 kg ha^{-1}). However

Table 1. Effect of different planting methods on yield parameters of cotton at location No. 1 (Bahawalpur)

Planting method	Plant Population/m^2	Sympodial Branches/plant	No. of opened bolls/plant	Boll weight (g)	Seed Index (g)
P_1	4.26	14.16	35.10 c	3.00	6.99
P_2	4.26	16.16	36.80 b	3.08	7.01
P_3	4.30	15.66	37.60 a	3.13	7.01
P_4	4.25	16.33	36.30 b	3.07	7.00
P_5	4.25	14.99	37.00 ab	3.11	7.01
P_6	4.30	15.31	37.00 ab	3.04	7.01
LSD	-	-	0.95	-	-

Means followed by the same letter in a column do not differ significantly at P≤ .05

Table 2. Effect of different planting methods on yield parameters of cotton at location No. 2 (Bahawalnagar)

Planting method	Plant Population/ m^2	Sympodial Branches/plant	No. of opened bolls/plant	Boll weight (g)	Seed Index (g)
P_1	3.98	12.00	23.00	2.81	6.96
P_2	3.97	10.50	24.83	2.95	7.02
P_3	4.00	11.65	26.16	2.99	7.03
P_4	4.00	12.00	23.83	2.94	7.01
P_5	3.99	12.00	22.66	2.94	6.97
P_6	4.00	10.00	23.00	2.92	7.01
LSD	-	-	-	-	-

Table 3. Effect of different planting methods on yield parameters of cotton at location No. 3 (Ahmadpur)

Planting method	Plant Population/ m^2	Sympodial Branches/plant	No. of opened bolls/plant	Boll weight (g)	Seed Index (g)
P_1	4.28	15.33	34.00	2.91	6.94
P_2	4.26	15.33	35.33	2.96	7.03
P_3	4.31	15.83	36.00	3.00	7.01
P_4	4.29	16.50	35.34	2.96	6.99
P_5	4.25	15.83	34.50	3.00	6.97
P_6	4.31	15.66	35.17	2.98	6.98
LSD	-	-	-	-	-

LSD Value at 5% Probability.

Table 4. Effect of different planting methods on seed cotton yield and water use efficiency at location No.1 (Bahawalpur)

Planting method	Seed Cotton Yield ($Kgha^{-1}$)	Total Water Used (I+R) (mm)	Water Use Efficiency ($kg\ ha^{-1}\ mm^{-1}$)
P1	2714.00 c	650	4.17 d
P2	2911.50 ab	637	4.57 c
P3	2991.00 a	531	5.63 a
P4	2819.00 c	543	5.19 b
P5	2863.00 b	632	4.53 cd
P6	2892.50 b	594	4.87 bc
LSD value	45.69	-	0.39

Means followed by the same letter in a column do not differ significantly at P≤ .05

Table 5. Effect of different planting methods on seed cotton yield and water use efficiency at location No.2 (Bahawalnagar)

Planting Method	Seed Cotton Yield ($Kgha^{-1}$)	Total Water Used (I+R) (mm)	Water Use Efficiency ($Kg\ ha^{-1}\ mm^{-1}$)
P1	2547.50	700	3.64 b
P2	2617.50	684	3.83 b
P3	2617.00	562	4.66 a
P4	2610.50	586	4.46 a
P5	2519.00	675	3.74 b
P6	2507.50	632	3.97 b
LSD value	-	-	0.37

Means followed by the same letter in a column do not differ significantly at P≤ .05

water use efficiency was significantly affected by planting methods. Highest value of 5.32 kg ha^{-1} mm^{-1} was recorded in P3 followed by P4 (5.21 kg ha^{-1} mm^{-1}) while lowest value of water use efficiency was observed in P1 (4.18 kg ha^{-1} mm^{-1}).

These findings are in consonance with those of Hearn (2000), Ertek and Kanber (2001), Goyne and McIntyre (2001), Terry A. Howell (2001) and Hood (2002). McAlavy (2004), Xi-ping Deng et al. (2004) and Bhattari (2005) reported that crop water use efficiency can be enhanced by sprinkler or drip irrigation systems.

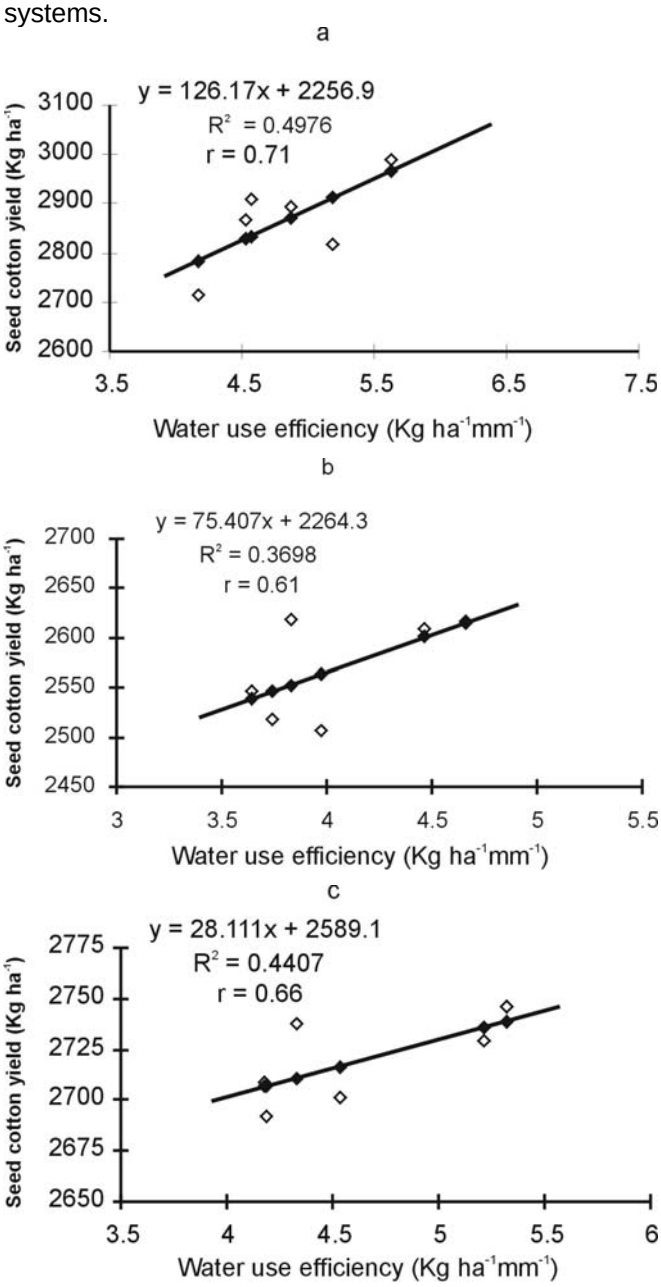

Fig. 1. Relationship between yield and water use efficiency at location 1(a), 2(b), 3(c) during 2005.

Fig.1 indicated the linear regression and co-relation between water use efficiency and seed cotton yield in case of different planting methods, predicting the better utilization of irrigation water by the crop plants to produce the maximum economic yield in case of various planting methods.

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