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PRODUCTION OF WINTER CEREALS AS RELAY CROPS BY SURFACE SEEDING IN COTTON BASED CROPPING SYSTEM

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Abstract: *Rabi* cereals were sown by surface seeding in standing water in one half of standing cotton and by conventional method in the second half after harvest of the cotton.

Relaying wheat by surface seeding produced 69.37% higher grain yield than sowing after harvest of cotton and by this technique increase in barley yield was 22.84% over conventional planting.

Yield, yield components, and quality traits of cotton were not affected significantly by any of the relay cropping systems. Substantially higher net field benefit was obtained from relay cropping system as compared to wheat followed by cotton. Among cotton based cereal production cropping patterns, cotton/wheat proved better relay cropping system.

Keywords: Barley, cotton, cropping system, rabi, relay, surface seeding, wheat.

INTRODUCTION

At present very low yield of *rabi* crops is the main cause of poor productivity of cotton-based cropping systems in Pakistan. The low productivity of *rabi* crops particularly that of cereals is ascribed to their very late sowing after harvest of cotton. Cotton is the most important cash crop of Pakistan and its early picking for timely sowing of *rabi* crops seems impossible [Govt. of Pakistan 2004]. This situation demands simultaneous increase of cotton and wheat. Delay in sowing of wheat and barley without disturbing our cash crop can be avoided by relaying *rabi crops* in standing cotton at optimum sowing time. Preliminary studies on relaying in standing cotton at zero tillage have shown promising results as it resulted in substantially higher yield than that of the conventional sowing after cotton harvest [ARI 1992]. However, further research on different cotton-based relay cropping systems is needed in order to develop new relay cropping systems and to evaluate their various agro-physiological and economic aspects. Hopefully such studies will lead to maximize the productivity and income of cotton growers with small landholdings. The objectives of this study were to determine the production potential and economics of cotton-based relay cropping of wheat and barley.

MATERIALS AND METHODS

This study was conducted at Research Area, Department of Agronomy, University of Agriculture, Faisalabad for two years i.e. during 1998-99 and 1999-2000. The experiment was laid out in randomized complete block design (RCBD) with four replications. Cotton was sown in 80 cm apart single rows in plots having net size of 9.6 m x 7 m. At the time of relaying each plot was further divided into two: one for relaying in standing cotton and second half for conventional late sowing after cotton harvest for wheat and barley separately.

First half of cotton plot pre assigned for relaying was irrigated to the depth of 7.5 cm. Barley (*Hordium vulgare* L.) cv. B.94057 and wheat (*Triticum aestivum* L.) cv. Inqilab 91 was sown on November, 15 and 18 during 1998 and 1999, respectively on no-tilled soil by a surface seeding technique in the standing cotton.

Table 1: Extra time available by adopting relaying as compared to conventional planting of cereals

Crops	Methodology	Crop Duration (Days)		
		1998-99	1999-2000	Average
Wheat	Relaying	162	158	160
	Conventional	113	117	115
	Extra days available for relay crop	49	41	45
Barley	Relaying	160	156	158
	Conventional	115	111	113
	Extra days available for relay crop	45	45	45

In relay cropping system a higher seed rate was used than recommended for the tilled seedbed. Thereafter, an adequate moisture supply was continued for facilitating seed germination and seedling establishment. Cotton sticks were cut deep and *rabi* crops relayed on no-tilled soil were also sown after preparing a fine seedbed conventionally on 31-12-98 and 02-01-99. Both the cereals were harvested at their physiological maturity.

The observation like plants m^{-2}, plant height (cm), fertile tillers unit $area^{-1}$, spike length (cm), grains $spike^{-1}$, 1000- grain weight, grain yield (kg ha^{-1}), biological yield (kg ha^{-1}) were recorded for evaluating the merits and demerits of relaying of *rabi* crops.

The data collected were transferred to the computer files for analysis. Analysis of variance (ANOVA) was accomplished by using MSTATC [Freed *et al.* 1991]. The two years average data were analyzed for economic parameters using the methodology described in CIMMYT [1988]. The partial budgets wre constructed for different cropping systems. The gross field benefits for each cropping system were calculated by multiplying the field prices by the yields, i.e.

Gross benefits = Field price x yield

Total costs that vary for each cropping system was calculated by adding up all the costs that vary for that system. The net benefits for each cropping system were calculated by subtracting the total variable cost from the gross field benefits i.e.

Net benefits = Gross benefits = Total cost that varies.

RESULTS AND DISCUSSION

PLANT POPULATION (m^{-2})

Relaying barley in cotton produced 91.8 plants m^{-2} that were statistically similar to 89.2 plants harvested from barley plots sown in late season after the harvest of cotton crop (Table 2). However, Harris [1984] reported reduction in plant population m^{-2} due to delay in sowing, but in the present study, due to increased seed rate than the recommended one in relay and conventional crops, similar plant populations were obtained.

Same pattern was observed in wheat Plant population (97.1 and 91.6 plants m^{-2}) (Table 2). The same plant density size in both relay (early sown) and conventional planting after cotton (late) was attributed to a higher seed rate used in both cases. This resulted in symmetry of plant numbers per unit area in both cases. In relay crop, a higher seed rate was used because there was no properly prepared firm seedbed to give normal germination. In the late sown wheat crop extremely low temperature prevailing at the germination stage may have lowered its percentage. Contrary to this [Waraich *et al.* 1982] reported that delay in sowing in wheat had a significant effect on germination. This can be ascribed to very low temperature disturbing germination physiology.

PLANT HEIGHT (cm)

On an average, plant height in barley and wheat ranged between 91.8–89.1 cm respectively (Table 2). In both cases although the difference in plant height of early (relay) and late sown (after harvest of cotton) could not reach to a significant level, however, comparatively shorter plants in case of late sown barley crop were attributed to a shorter solar radiation interception period by the late sown crop [Hay and Walker 1989]. However, Razzaq *et al.* [1986] reported that plant height of wheat sown on 15th December was significantly reduced as compared to that sown on 31st October. They were of the opinion that his reduction was due to lower temperature in late sown crop that suppressed the normal growth of plant.

FERTILE TILLERS PLANT^{-1}

Method and time of sowing had a significant effect on fertile tillers of barley. Relaying barley in cotton increased number of fertile tillers plant^{-1} as compared to conventional sowing after the harvest of cotton. Fertile tillers plant^{-1} were 2.39 and 2.13 in relayed and sown after the harvest of cotton, respectively (Table 2). A fewer fertile tillers in barley sown after the harvest of cotton were attributed to the delay in sowing. Each stage of development was progressively reduced with delay in sowing which reduced the fertile tiller plant^{-1} [Noworolnik 1989 and Noworolnik and Pecio 1990].

Trend of tiller formation in wheat was in line with that of barley. Wheat relayed in cotton produced a significantly greater number of fertile tillers plant^{-1} (3) as compared to wheat sown after the harvest of cotton (2.48)

(Table 2). Reduction (17.3%) in fertile tillers plant^{-1} in wheat sown after harvest of cotton might be attributed to delay in sowing. Decrease in fertile tillers plant^{-1} in late sown wheat was due to changes in temperature, from November 15 to December 30. Rate of leaf initiation and appearance on main column are linearly related to temperature of the shoot meristem [Ong and Barker 1985]. The development of the late sown crop was accelerated which implied that duration of each stage of development was progressively reduced with delay in sowing. Kirby and Ellis [1980] reported that delay in sowing resulted in decline in number of leaves stem^{-1}, because of the decrease in the length of the period of leaf initiation that in turn reduced the number of tillers initiated.

SPIKE LENGTH (cm)

Time of sowing did not affect spike length in wheat and barley significantly. However, on an average barley crop relayed in cotton gave slightly a longer spike length (8.08 cm) against that recorded for barley (7.61 cm) sown after the harvest of cotton crop (Table 2). Similar spike length in barley was recorded during both years under study.

Table 2: Performance of cereals under relay and conventional planting in cotton based cropping System.

Parameters	M_1		M_2		Sx	
	Barley	Wheat	Barley	Wheat	Barley	Wheat
Plant density (m^{-2})	91.8^{ns}	97.1^{ns}	89.2	91.6	2.10	1.75
Plant height (cm)	91.8^{ns}	96.3^{ns}	89.1	91.3	1.74	1.77
Fertile tillers plant^{-1}	2.39^{a}	3.0^{a}	2.13^{b}	2.48^{b}	0.05	0.06
Spike length (cm)	8.08^{ns}	11.0^{ns}	7.61	10.3	0.15	0.22
Grain spike^{-1}	32.1^{a}	31.2^{a}	30.^{b}	26.3^{b}	0.55	0.51
1000-grain weight (g)	25.3^{ns}	37.0^{a}	25.2	32.7^{b}	0.65	0.64
Grain yield (kg ha^{-1})	1549^{a}	2964^{a}	1261^{b}	1750^{b}	25.9	52.8
Biological yield (kg ha^{-1})	4924^{a}	8923^{a}	4016^{b}	5486^{b}	158.0	147.0
Harvest index (%)	31.5^{ns}	33.2^{ns}	31.4	31.9	1.29	0.10

M_1= relaying at optimum time in standing cotton, M_2 = late sowing after harvest of cotton,
Figures followed by different letters are significantly different at 0.05 probability levels using LSD.
ns = non-significant

Again difference of spike length of wheat crop sown with two methods did not reach to a significant extent. However, a slightly greater spike length (11) was recorded for wheat relayed in cotton as compared with 10.3 cm long spikes recorded for wheat sown after harvest of cotton crop (Table 2). A wheat crop relayed in cotton and sown after harvest of cotton passed through each developmental stage at different times and, therefore, under different environmental conditions (especially temperature). Probably spike development was slightly favored by the conditions prevailing in the relayed crop than the crop sown after harvest of wheat.

GRAINS SPIKE^{-1}

Number of grains spike^{-1} increased significantly when barley (32.1) and wheat (31.2) were sown as a relay crop as against 30 grains spike^{-1} recorded for barley sown after the harvest of the cotton crop (Table 2). The temperature and available time for anthesis, grain formation and grain filling increased the number of grains spike^{-1} in case of the relay crop of barley as compared to the late sown crop. Thus in the case of relay sowing, significantly more grains spike^{-1} were recorded than those recorded for late sowing of barley after the cotton crop harvest. Kirby [1969] and Noworolnik [1989] reported similar effects of late sowing. Similar number of grains spike^{-1} was recorded for the barley crop during both years under study.

A significantly greater number of grains spike^{-1} were recorded for wheat relayed in cotton as compared with that sown after the harvest of cotton (26.3 grains spike^{-1}) (Table 2). A fewer number of grains spike^{-1} in the crop sown after harvest of cotton was attributed to a higher temperature at anthesis and grain development stages and less time for grain formation as compared with wheat relayed in cotton. The latter crop passed through all the growth stages at normal temperature optima and each development stage was completed in normal duration that resulted in a greater number of grains. Delay in sowing date is commonly found to have a negative influence upon the number of grains year^{-1} [Jan *et al.* 2000].

1000-SEED WEIGHT (g)

Thousand seed weight was not influenced significantly by time and sowing method of barley. On an average 1000-seed weight was slightly higher (25.3 g) in the barley crop relayed in cotton as compared to 25.2 g for the barley crop sown after the harvest of the cotton crop (Table 2). Individual grain weight for a given cultivar is a relatively stable character [Gallagher *et al.* 1975]. Although the number of grains spike^{-1} was increased in relayed crop no increase in grain weight was recorded.

Relay strategy produced 13.2% higher 1000-grain weight as compared to conventional sowing of wheat crop (Table 2). This can be attributed to a longer grain filling period available to the early sown crop. Green *et al.* [1985], and Angus and Sage [1980] found that grain weight was reduced by late sowing up to about 10%. Khan [1986] and Jan *et al.* [2000] reported that 1000-grain weight decreased significantly with delay in sowing. Individual grain weight for a given cultivar is a relatively stable character [Gallaghar *et al.* 1975].

GRAIN YIELD (kg ha^{-1})

Relaying of barley in cotton produced significantly a higher grain yield (1549 kg ha^{-1}) as compared with that harvested from the barley crop sown after the harvest of cotton (1261 kg ha^{-1}) (Table 2). Increase in grain yield in the early crop was attributed primarily to significantly more fertile tillers plant^{-1}, grains spike^{-1} and a comparatively better plant population, 1000-seed weight as compared with the barley sown after the harvest of cotton. The barley crop relayed in cotton found a favourable environment for germination and subsequent growth and development. Moreover each developmental stage passed through an adequate duration to complete its cycle that allowed this crop to explore its potential. In a late sown crop, each developmental stage not only experienced unfavorable temperature but the duration for each stage was also reduced, resulting in less exploitation of the potential [Noworolik and Pecio 1990 and Conry and Hegarty 1992].

Wheat relayed in cotton gave a significantly higher grain yield of 2964 kg ha^{-1} against 1750 kg ha^{-1} grains harvested for wheat sown after the harvest of cotton (Table 2).

Higher grain yield (69.4%) of wheat relayed in cotton was attributed primarily to a 6% higher plant density, 21% more fertile tillers plant^{1}, 18.6% grains spike^{-1} and 13.2% higher 1000-grain weight as compared with the wheat crop sown after the harvest of the cotton. The wheat crop relayed into cotton experienced a favorable temperature for germination, crown root development and subsequent developmental stages. The crop sown after harvest of cotton not only faced an unfavorable temperature regime but also a smaller growth duration period of about 1.5 month. All these factors influenced the performance of wheat sown after harvest of cotton-late sown [Akkaya and Akten 1989, Piech and Stankowski 1989, Andrew *et al.* 1990, Stapper and Fischer 1990]. Reduction in wheat grain yield sown by conventional method (after harvest of cotton) over that relayed in cotton has also been reported by CRI [1993] and was attributed to unfavorable temperatures in the case of late sown wheat.

BIOLOGICAL YIELD (kg ha^{-1})

A significantly greater biological yield (4924 kg ha^{-1}) was recorded for barley relayed into cotton as compared to that sown after the harvest of cotton (4016 kg ha^{-1}) (Table 2). The increase in biological yield of barley relayed in cotton was attributed to timely sowing as compared with that sown after the harvest of the cotton. The relayed crop into the cotton not only experienced a favorable temperature but also a normal duration to pass through various developmental stages. The duration of developmental stages was reduced in the late sown barley. Statistically similar biological yields were recorded during both years under study.

Relaying wheat in cotton significantly increased its biological yield (8923 kg ha^{-1}) (Table 1) as compared to wheat sown after the harvest of cotton crop (5486). Wheat sown in standing cotton gave a comparatively better plant stand, greater plant height and other plant growth factors. This was due to the optimum temperatures experienced at all stages of growth and development. In contrast to this the wheat sown after the harvest of cotton not only missed these temperature optima but the crop had to complete all its growth stages in a shorter time available for the maturity. All these factors reduced the performance of wheat sown after harvest of cotton and hence gave less biological yield. Biological yield was statistically similar during both years under study.

HARVEST INDEX (%)

Sowing methods of barley did not influence its harvest index. Interactive effect of years x sowing methods on harvest index of barley was also non-significant. Different sowing methods of wheat at different times did not influence the harvest index, which was 33.2 and 31.9% for wheat relayed in cotton and sown after the harvest of the cotton crop, respectively (Table 2). However, Stapper and Fischer [1990] reported improved harvest indices in wheat in delayed sowing. Similar harvest indices were recorded during both years under study.

CONCLUSION

Relaying of wheat in standing cotton produced 1214 kg ha^{-1} extra wheat as compared to its conventional sowing after harvest of cotton. In monetary terms farmer got ten thousand extra rupees per hectare by adopting relay strategy for timely sowing of cereals.

References

AARI. **(1992)** "Annual Report", Ayub Agricultural Research Institute, Faisalabad, Pakistan.

Akkaya, A. and Akten, S. (**1989**) "Effect of different sowing dates on the yield and some yield components of winter wheat under dryland conditions at Frzurum", Tarla bitkileri, Boluu, Ataturk Universitesi, Fruzurm, Turkey.

Andrew, Y., Hulluka, M. and Ahmad, S. (**1990**) "Effect of sowing dates on severity of leaf and stem rust and on yield of wheat at Debre Zeit", *Sixth Regional Wheat workshop for Eastern, Central and Southern Africa*, 4, 59-62.CIMMYT, Mexico.

Angus, W.J. and Sage, G.C.M. (**1980**) "Patterns of yield production in two semi-dwarf and two conventional European spring wheats", *J. Agricultural Science, Cambridge*, 9, 387-393

C.R.I. (**1993**) "Annual Summary Report", Cotton Research Institute, Multan, Pakistan.

CIMMYT (**1988**) "From agricultural data to farm records-an economic manual", Economics programme, CIMMYT, Maxico.

Conry, M.J. and Hegarty, A. (**1992**) "Effect of sowing date and seed rate on the grain yield and protein contents of winter barley", *J. Agric. Sci.*, 118(3), 279-287.

Freed, R., Eisensmith, S.P., Goetz, S., Reicosky, D., Smail, V.W. and Welberg, P. (**1991**) "Users' Guide to M STAT-C", Michigan State University, East Lansing, MI, USA.

Gallagher, J.N. Biscoe, P.V. and Scott, R.K. (**1975**) "Barley and its environment-Stability of grain weight", *J. Applied Ecology*, 12, 319-36.

Government of Pakistan (**2004**) "Economic Survey of Pakistan", Finance Division, Economic Wing, Islamabad, Pakistan.

Green C.F., Paulson, G.A. and Ivins, J.D. (**1985**) "Time of sowing and the development of winter wheat", *J. Agric. Science, Cambridge*, 105, 217-221.

Harris, P.B. (**1984**) "The effect of sowing date, disease control, seed rate and the application of plant growth regulators and of autumn nitrogen on the growth and yield of winter barley", *Research and Development in Agriculture*, 1, 21-27.

Jan, A., Hammed, I. and Muhammad, T. (**2000**) "Seed rates and sowing dates effect on the performance of wheat variety Bakhatawar-92", *Pak. J. Biol. Sci*., 3(9), 1409-1411.

Khan, A. and Saleem, M. (**1986**) "Grain yield as influenced by seeding dates in wheat", *Pak. J. Agric. Res*., 7, 14-16.

Kirby, E.J.M. (**1969**) "The effect of sowing date and plant density on barley", *Annals of Applied Biology*, 63, 513-521.

Kirby, E.J.M. and Ellis, R.P. (**1980**) "A comparison of spring barley grown in England and Scotland-Shoot apex development", *Journal of Agric. Science, Cambridge*, 95, 101-110.

Noworolnik, K. (**1989**) "Sowing date effect on spring barley grain yield and its structure", Biuletyn - Instytute Hodowli-I-Akl.

Noworolnik, K. and Pecio, A. (**1990**) "Effect of N fertilizer application and sowing date and rate on the magnitude and structure of grain yield of winter barley cultivars", *Biuletute- Instytute Hodowli-I- Aklimatyzacji-Roslin*, 175(11), 55-62.

Ong, G.K. and Baker, N.R. (**1985**) "Control of Leaf Growth", Temperature and Leaf Growth", Cambridge University Press, pp. 175-200.

Piech, M. and Stankowski, S. (**1989**) **"**Effect of sowing dates and rate on yield and grain quality of winter wheat varieties", *Biuletyn-instytutu-Hodowli-i-Aklimatyzacji-Roslin*., 169(13), 137-147.

Razzaq, A., Shah, P., Sartaj, M., Saeed, K. and Muhammad, D. (**1986**) **"**Effect of planting time on yield and straw of wheat varieties", *Sci. J. Agric*., 2, 327-334.

Stapper, M. and Fischer, R.A. (**1990**) **"**Genotype, sowing date and plant spacing influence on high yielding irrigated wheat in Southern New South Wales", *Australian J. Agric. Res*., 41(6), 1021-1041.

Waraich, S.A. Yasmin, S. and Ashraf, S. (**1982**) "Genetic parameters influenced by seeding dates in wheat", *Pak. J. Agri. Res*., 3, 273-276.