EFFECT OF SEEDING RATE AND SEED SOAKING DURATION ON PRODUCTIVITY OF RELAY- INTERCROPPED WHEAT IN COTTON

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ABSTRACT: The major problem in cotton-wheat cropping system is delayed harvesting of cotton which results in late planting of wheat. Therefore, a field experiment was conducted on relay wheat in standing cotton that comprised of three different seeding densities (100, 125 and 150 kg ha^{-1}) and four seed soaking durations (0, 6, 12 and 18 hours). The experiment was designed in randomized complete block design with factorial arrangement having three replications. The interactive effect of seed rates and seed soaking duration on emergence count, leaf area index, spikelet's per spike, grains per spike and grain yield were significant. Wheat sown with seed rate of 150 kg ha^{-1} and 12 hrs of seed soaking produced significantly higher yield than all other combinations except for 125 kg ha^{-1}seed rate and 12 and 18 hrs of seed soakings. In conclusion, the productivity of relay wheat in standing cotton can be enhanced by using seed rate of 150 kg ha^{-1} along with seed soaking duration of 12 hours.

Key words: Seeding density, Soaking duration, Cotton, Relay-wheat, growth and yield.

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INTRODUCTION

Wheat is the main staple food crop in Pakistan. In terms of total grain production, grain yield per hectare and area under wheat cultivation, Pakistan falls in top ten countries of the world (Anjum *et al*., 2008). It is the daily intake of about 60% population in Pakistan. About 15.4% proteins, 1.9% fats, 68% carbohydrates and 12.2% dietary fiber are present in wheat grain (Anjum *et al*., 2008). Cotton-wheat is the second major system cropping system in south Asia followed by rice wheat system. This system helps in providing local food security and economic uplift by earnings foreign exchange through export of cotton (Anjum *et al.,* 2008).

In cotton-wheat cropping system, one of the major constraint of low yield of wheat is delayed sowing due to the late harvesting of cotton. A decrease of 1-1.5% in wheat yield is observed when wheat was sown after 20th November (Nasrullah *et al*., 2010). Late planted crop leads to poor germination, less number of tillers, shriveled grains and less biomass production (Ugarte *et al*., 2007). Late sown wheat seed weight is reduced due to high temperature at grain filling stage (Anwar *et al*., 2011).

In cotton-wheat cropping system, relay sown wheat can be a suitable strategy to avoid the late sowing of wheat. Benefits of relay cropping include timely sowing, attainment of more net income per unit area, ecological and biological pest control, yield compensation and increased soil productivity (Wallace *et al*., 1992).

Higher seed rate of wheat is required to compensate the problem of low seed germination and number of tillers per unit area. High seed rate plays an important role for assurance of the optimum plant population leading to comparable yield of wheat in relay cropping. The wheat seed soaking in water like seed priming can be helpful to overcome the problem of low seed germination in relay wheat in standing cotton. The seed priming substantially improved the seed germination and stand establishment and thereby improved the crop growth and yield (Basra *et al*., 2005). Therefore, present field trial was conducted to find a suitable seeding rate and soaking duration for relay sown wheat seed in standing cotton crop.

MATERIALS AND METHODS

The experiment was carried out at Postgraduate Agricultural Research Station, University of Agriculture Faisalabad during winter season (Rabi Season) 2014-15 to assess the best combination of optimum seed rate and soaking period of wheat seed in water for relay sown wheat in standing cotton. The composite soil samples were analyzed for their physiochemical parameters by using the procedure described by Homer and Pratt (1961). The soil was sandy loam having organic matter 1.11%, pH 7.85, EC 1.68dS m^{-1}, nitrogen 0.021%, phosphorus 11 mg kg^{-1} and potassium 114 mg kg^{-1}, respectively.

Table 1. Mean monthly temperature, relative humidity (R.H) and rainfall during wheat growing season.

Months	Monthly Mean Max. Temp (°C)	Monthly Mean Min. Temp (°C)	Monthly Avg. Temp (°C)	R.H (%)	Rainfall (mm)
Dec-21014	18.5	5.9	12.2	75.0	0.0
Jan-2015	16.6	6.9	11.7	75.3	12.2
Feb-2015	22.0	11.1	16.5	66.0	20.5
Mar-2015	24.5	13.6	19.1	64.0	67.9
Apr-2015	33.2	20.7	27.0	43.9	32.8

The experimental site was under semi-arid region, and prevailing climatic conditions during the crop growth season are presented in Table (1). The experiment comprised of four seed soaking durations, i.e. 0, 6, 12 and 18 hours and three seeding rates, *viz.* 100, 125 and 150 kg ha^{-1} for wheat crop. The proposed investigation was conducted in randomized complete block design in factorial arrangement with three replications.

Crop husbandry: Seed of wheat cultivar (Punjab, 2011) was collected from Punjab Seed Corporation. The seed was dried for one hour after soaking in water for respective duration of treatments and then different rates according to treatments were broadcasted in standing water (last irrigation to cotton) in standing cotton. The crop was sown on 1st of November. Cotton sticks were harvested post 30 days of sowing of wheat. The recommended dose of NPK was applied at the rate of 150:100:50 kg ha^{-1}. Nitrogen was used in the form of urea (46% N), while phosphorus and potassium in the form of single super phosphate (14% P_2O_5) and sulphate of potash (50% K_2O) respectively. Full dose of phosphorus, potash and half of nitrogen was applied as basal dose, while the left over nitrogen with second irrigation.

The data regarding emergence count was taken 10 days after sowing from selected three places of 1 meter square from each replication. The leaf area was measured by graph paper method. To calculate the total dry matter, ten randomly selected tillers were harvested from each plot and placed in sunlight for two days, dried in oven for 72 hours at 72°C and weighed. Oven-dried weight of ten tillers was multiplied with the total number of tillers in square meter and converted to tons per hectare mathematically. The wheat crop was harvested on 21st April, 2015. Number of fertile and non-fertile tillers was counted from an area of square meter. Similarly, ten spikes were selected at random from each plot to calculate, spike length, spikelet's and grains per spike. Grain yield, biological yield and harvest index were calculated following standard procedures.

Statistical analysis: The data was analyzed by Fisher's analysis of variance technique and treatment means compared by least significant difference (LSD) test at 5% probability level (Steel *et al*., 1997).

RESULTS AND DISCUSSION

The influence of different seed rates and soaking duration on germination count was found significant. The maximum germination count m^2 was recorded at seed rate of 150 kg ha^{-1}, whereas, 100 kg ha^{-1} produced least number of seedlings (Table 2). Significantly higher germination count was recorded with soaking of wheat seed for 12 hours while, lowest (121.22) in case of without seed soaking. Present findings are similar with Harris *et al*. (2001) by soaking seed for 12 hours in tap water, increased the germination of wheat seed. In interactive effect, the maximum emergence count was found with the seed rate of 125 kg $ha^{-1}$and soaking duration for 12 hours, similarly, the minimum emergence count was recorded in plots, where seed was sown without soaking at the rate of 100 kg ha^{-1}.

The leaf area index (LAI) was significantly affected by seed rate treatments. At 90 days, the maximum LAI was recorded where seed rate of 150 kg $ha^{-1}$was used for sowing and lowest for 100 kg $ha^{-1}$of seed rate (Table 2). The findings are in consistent with results of Tajul *et al*. (2013), that increase in seeding rate substantially increased the leaf area index and total dry matter production in maize. The interactive effect of seed rate and soaking duration for LAI was found significant. In interactive effect, seed rate of 150 kg ha^{-1} soaked for12 hours provided maximum LAI, while the minimum at the rate of 125 kg/ha without soaking treatment.

Similarly, 150 kg ha^{-1} produced higher total dry matter (TDM) compared to other treatments (Table 2). Moreover, soaking duration had a significant on the TDM production. Maximum TDM (1019.7 g m^{-2}) was produced when seed soaked for 12 hours while minimum by no soaking. The findings are in confirmation with the study of Tajul *et al.* (2013), that an increase in seed rate, substantially increased LAI and TDM.

Maximum fertile tillers (287.22) and spike length (11.39 cm) was recorded by using seed rate of 150 kg ha^{-1},whereas, minimum fertile tillers (264.36) and spike length (9.56 cm) were recorded at seed rate of 100 kg ha^{-1} (Table 2). The soaking for 18 hours produced maximum number of fertile tillers (294.18) while minimum value (265.52) was recorded where the seeds were sown without soaking treatment. Moreover, soaking

durations had non-significant effect on the spike length of the relayed wheat. These findings are also agrees as depicted by Laghari *et al.* (2011), Iqtidar *et al*. (2010) and Ahmad *et al*. (2007) whom found the substantial increase in spikelet's per spike by increasing the seed rates of wheat crop.

The seed rate has significant effect on the spikelet's per spike of relay sown wheat. The maximum spikelet per spike was found where the wheat was sown @ 150 kg ha^{-1} that was also comparable with 125 kg ha^{-1} treatment while the minimum was in 100 kg ha^{-1}(Table 2). The soaking duration of seed in water also had significant effect on spikelet per spike of wheat. Maximum spikelet per spike was found when wheat seed was soaked for 12 hours and other soaking duration of wheat seed were statistically comparable with each other. These findings are in line with previous results of Harris *et al.* (2001), who found maximum spikelet's with water soaking for 12 hours. In interactive effect of seed rate and soaking duration, maximum spikelet per spike was found where a seed rate of 100 kg/ha was used with the soaking duration of 12 hours, similarly the minimum number of spikelet per spike was recorded where the seed was used at the rate of 100 kg/ha with no soaking (Table 3).

Experimental data showed that highest number of grain spike^{-1} produced with seed rate of 125 kg ha^{-1} while significantly lower value was found at seed rate of 100 kg ha^{-1} than that of other tested seed rates. These findings are same as depicted by Wajid *et al.* (2011) they reported that the number of grains per spike decreased with increasing seed rate. The effect of soaking duration was also significant for grains spike^{-1}. The maximum grains per spike were found when seed was soaked for duration of 12 hours. These findings are in consistence with previous results of Harris *et al* .(2001) who found that seed soaking in water for 12 hours gave better results like more grains per spike. In interactive effect seed rate of 150 kg ha^{-1} with the soaking duration of 12 hours gave maximum grains spike^{-1} (Table 3).

Soaking duration markedly affected the grain and biological yields of relayed wheat. The highest grain (4.17 t ha^{-1}) and biological yield (11.17 t ha^{-1}) was obtained with seeds soaked for 12 hours and the minimum values of grain and biological yield were recorded where seeds were sown without soaking (Table 2). The similar results were reported by Saeed *et al.* (2000); where maximum grain yield of wheat was obtained in plots sown after12 hours of seed soaking and sown in standing sunflower. Different seed rates also had considerable influence on the grain and biological yield of relay wheat crop. The maximum grain (3.98 t ha^{-1}) and biological yield (11.11 t ha^{-1}) were recorded with seed rate of 150 kg ha^{-1} and minimum were obtained by using seed rate of 100 kg ha^{-1} (Table 2). Nazir *et al.* (2000) also found that 150 kg seed rate of wheat produced significantly higher grain yield under late sown condition than lower seed rates. Similarly, Arif *et al.* (2003) also found that increase in seed rate substantially, increased the crop yield in wheat. Interaction between soaking duration and seed rate was also found significant for grain yield and non-significant for biological yield of wheat. The maximum grain yield was recorded with seed rate of 150 kg ha^{-1}along with soaking of seeds for 12 hours while the minimum was recorded where 100 kg ha^{-1}seed was sown without soaking or for 6 hours (Table 3).

Table 2. Effect of Seed Rate and Seed Soaking Duration on Productivity of Relay-intercropped Wheat in Cotton.

Treatments	Emergence count	Leaf Area Index	TDM	Fertile tillers	Spike length (cm)	Spikelet's per spike	Grains per spike	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})
Soaking duration (SD)									
SD_1= Control	121.22 ^{b}	2.83 ^{d}	553.0 ^{d}	265.52 ^{c}	10.48	15.54 ^{b}	35.56 ^{b}	3.56 ^{c}	9.641 ^{c}
SD_2= 6 hours	122.28 ^{b}	3.60 ^{c}	752.7 ^{c}	264.85 ^{c}	10.30	15.96 ^{b}	35.96 ^{b}	3.62 ^{c}	10.03 ^{bc}
SD_3= 12 hours	130.72 ^{a}	5.04 ^{a}	1019.7 ^{a}	279.11 ^{b}	10.35	16.93 ^{a}	39.00 ^{a}	4.17 ^{a}	11.17 ^{a}
SD_4= 18 hours	122.00 ^{b}	4.29 ^{b}	850.2 ^{b}	294.18 ^{a}	10.47	16.00 ^{b}	36.44 ^{b}	4.03^{b}	10.64 ^{b}
LSD (P ≤0.05)	**4.32**	**0.5**	**88.01**	**11.28**	**NS**	**0.64**	**1.12**	**0.09**	**0.83**
Seed Rates (SR)									
SR_1= 100 kg ha^{-1}	118.88 ^{c}	3.03 ^{c}	542.5 ^{c}	264.36 ^{c}	9.56 c	15.42 ^{b}	36.33 ^{b}	3.68 ^{c}	9.69 ^{c}
SR_2= 125 kg ha^{-1}	124.38 ^{b}	3.80 ^{b}	769.7 ^{b}	276.16 ^{b}	10.26 ^{b}	16.25 ^{a}	37.83 ^{a}	3.88 ^{b}	10.32 ^{b}
SR_3= 150 kg ha^{-1}	128.92 ^{a}	4.98 ^{a}	1069.4 ^{a}	287.22 ^{a}	11.39 ^{a}	16.65 ^{a}	36.05 ^{b}	3.98 ^{a}	11.11 ^{a}
LSD (P ≤0.05)	**3.74**	**0.43**	**76.22**	**9.77**	**0.75**	**0.55**	**0.97**	**0.08**	**0.72**

Means sharing the same letter for a single parameter do not differ significantly at P ≤ 0.05.

Table 3. Interactive effect of Seed Rate and Soaking Duration on the Productivity of Relay-intercropped Wheat in Cotton.

Treatments	Emergence count	Leaf Area Index	TDM	Fertile tillers	Spike length (cm)	Spikelet's per spike	Grains per spike	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})
SD_1									
SR_1	112 ^{e}	2.98 ^{gh}	387.0 ^{g}	256.66	9.80	13.89 ^{f}	35.12 ^{d}	3.43 ^{g}	9.73
SR_2	125.5 ^{bc}	1.99 ^{i}	680.7 ^{de}	265.78	10.00	16.22 ^{bcd}	37.22 ^{bc}	3.47 ^{fg}	9.35
SR_3	126.17 ^{bc}	3.49 ^{efg}	591.2 ^{e}	274.11	11.63	16.5^{abc}	34.33 ^{d}	3.77 ^{de}	9.85
SD_2									
SR_1	117.67 ^{de}	2.34 ^{hi}	429.8 ^{fg}	265.89	9.26	15.22 ^{de}	35.33 ^{cd}	3.37 ^{g}	9.42
SR_2	122.33 ^{bcd}	3.19 ^{fgh}	633.9 e	258.55	10.19	16.56 ^{abc}	37.44 ^{b}	3.63 ^{ef}	10.23
SR_3	126.83 ^{bc}	5.28 ^{bc}	1194.6 ^{ab}	270.11	11.47	16.^{11bcde}	35.11 ^{d}	3.87 ^{cd}	10.47
SD_3									
SR_1	123.67 ^{bcd}	2.83 ^{ghi}	792.8 ^{cd}	265.11	9.26	17.^{45a}	39.44 ^{a}	3.93 ^{cd}	10.07
SR_2	128.67 ^{b}	5.83 ^{ab}	931.6 c	284.78	10.41	16.56 ^{abc}	38.00 ^{ab}	4.27^{a}	11.4
SR_3	139.83 ^{a}	6.48 ^{a}	1334.6 ^{a}	287.44	11.39	16.78 ^{ab}	39.55 ^{a}	4.3 ^{a}	12.03
SD_4									
SR_1	122.17 ^{bcd}	3.99 ^{def}	560.5 ^{ef}	269.78	9.90	15.11^{e}	35.44 ^{cd}	4 ^{bc}	9.53
SR_2	121.00 ^{cd}	4.19 ^{de}	832.8 ^{cd}	295.55	10.42	15.67 ^{cde}	38.67 ^{ab}	4.13 ^{ab}	10.29
SR_3	122.83 ^{bcd}	4.69 ^{cd}	1157.1 ^{b}	317.22	11.09	17.22 ^{ab}	35.22 ^{d}	3.97 ^{bc}	12.1
LSD (P ≤0.05)	**7.48**	**0.87**	**152.44**	**NS**	**NS**	**1.11**	**1.94**	**0.16**	**NS**

Means sharing the same letter for a single parameter do not differ significantly at $P \leq 0.05$.
SD_1= Control, SD_2 = 6 hours, SD_3 = 12 hours, SD_4 = 18 hours; SR_1 = 100 kg ha^{-1}, SR_2 = 125 kg ha^{-1}, SR_3= 150 kg ha^{-1}

Conclusion: The seed rate of 150 kg ha^{-1}along with 12 hours of seed soaking helped to get maximum plant population, growth, yield and yield related attributes of relayed wheat in standing cotton.

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