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COVER CROP MANAGEMENT PRACTICES: IMPLICATIONS FOR EARLY SEASON WEED CONTROL IN CONSERVATION TILLAGE CORN COTTON ROTATION

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Abstract

Use of the winter cover crops is an integral component of the conservation systems in corn (*Zea mays* L.) and cotton (*Gossypium hirsutum* L.). A field experiment was initiated in 2004 to evaluate weed suppression provided by winter cover crops in a conservation tillage corn and cotton rotation. Rotation for winter cover crops included clover (*Trifolium incarnatum* L.) preceding corn and rye (*Secale cereale* L.) preceding cotton. Both covers were planted at five different planting dates with the median date corresponding to the thirty year average first frost. Termination dates in the spring were 4, 3, 2 and 1 week prior to cash crop planting, based on thirty year average soil temperature. Results showed a dramatic impact on biomass production with even a week's delay in winter cover crop planting and corresponding reduction in summer annual weed suppression. More than ten times difference in biomass produced by clover was observed when clover was planted on the earliest and terminated on last date compared to late planting and early termination. Rye produced almost eight times more biomass in the same comparison. Correspondingly, weed biomass was 556 kg/ha in the treatment with least rye biomass, 8 times higher compared to the treatment with greatest rye biomass. Weed populations observed in clover were less than in rye even though the difference was only 34 kg/ha in case of clover. The data for the first two years show no significant relationship between cover crop biomass and the cash crop yield.

Introduction

Use of conservation tillage systems for cotton and corn production has become increasingly popular in the last two decades primarily to address concerns of decreasing air and water quality and soil productivity. Use of high residue cover crops is an integral component of conservation tillage systems. Cover crop residue provides soil with a cover which plays a vital role in reducing erosion, improving infiltration, soil moisture retention carbon sequestration, increasing soil organic matter and nutrient recycling (Blevins et al. 1971; Bradley 1995; Kaspar et al. 2001; Reeves 1997). Raper et al. (2003) in research conducted on Coastal Plain soils in southeastern USA established that it is essential to include cover crops as an integral part of conservation tillage cotton systems.

Effective weed management throughout the growing season is a critical component in cotton production. Cotton can not compete effectively with weeds early in the season and presence of weeds late in the season can reduce the harvesting efficiency and can also adversely impact the lint quality. Approximately 90% of the cotton grown in United States in 2001 received herbicides (Anonymous 2002). Development of herbicide resistant weed species and shift in the weed populations are the results of such extensive chemical control. Practical alternatives to the intensive use of herbicides for controlling weeds in cotton production therefore offers economical as well as environmental benefits.

Winter cover crops also play an important role in weed suppression. Weed control by using cover crops is gaining more importance in today's conservation tillage systems when an increasing number of weed species are acquiring resistance to herbicides. Previous research has shown that early season weed control by using cover crops with conservation tillage systems is comparable to chemical control in many situations (Teasdale and Mohler, 1992; Johnson et. al. 1992). The degree of weed control provided by a cover crop depends on the management strategies.

Living mulch cover crops suppress weeds by competition and by changing the light transmittance and soil temperature regimes (Teasdale and Daughtry, 1993). When killed, the cover crop residue act as a physical barrier and creates conditions where it is difficult for the weed seeds to emerge and establish. Previous research has shown that cover crops also suppress weeds through chemical allelopathic effects; however, field activity has not been widely documented due to difficulty of isolating the allelopathic effects from the physical mulch effects in field situations (Inderjit et al. 2001; Putnam et al. 1983).

Cereal rye (*Secale cereale* L.) and soft red winter wheat (*Triticum aestivum* L.) are two common winter cover crops recommended for cotton production in the southeastern United States. Both of these covers have been shown to possess allelopathic activity against weeds (Akemo et al., 2000; Perez and Ormeno-Nunez, 1991). Black oat (*Avena strigosa* Schreb.) has recently been introduced in the southeastern U.S. through a joint release between Auburn University and The Institute of Agronomy of Paraná, Brazil, and is currently marketed as "SoilSaver black oat" (Bauer and Reeves 1999). Recent research by Price et al. (2006) and Reeves et al. (2005) evaluated black oat, compared to rye and wheat in conservation-tillage cotton and soybean. Results in both experiments showed that black oat biomass and weed suppressive potential is comparable to rye and greater than wheat, allowing for reduced herbicide input. Crimson clover, Austrian winter peas and vetch are the recommended cover crops for corn and they have also been shown to possess allelopathic activity (Stoll et al 2006).

Crop rotation is also an important component of the cotton production in the southeast as continuous cotton production causes many problems including increased soil borne pathogen populations. Lack of herbicide chemistry rotation also results in increased number of resistant weed species. Crop rotation can be an effective tool in reducing the buildup of problematic weeds and to keep their population under control. Using crop rotations with an effective herbicide program can help alleviate these problems. Rotations with corn are typical, due to the lower production costs, ease of production, and because corn is a non-host to many cotton pathogens.

Weed control benefits associated with cover crops can be improved by increasing the amount of residue on the field, but this can also result in some negative effects. High residue can interfere with cash crop establishment and can also deplete the soil moisture (Teasdale, 1993; Liebl et al. 1992). The dense residue can also lead to a decrease in soil temperature which can severely impact the cash crop yield. Therefore having an optimum amount of residue on the soil is the key to have the maximum benefits from the cover crop system.

Historically, cover crop planting and termination have occurred at the discretion of growers' schedules and weather conditions. Research has shown that a winter cover's planting date and termination date has influence on both quality and quantity of residue production, and hence may affect subsequent weed suppression. A field study was conducted to determine optimum dates for planting and terminating cover crops so as to maximize biomass production and soil coverage, early season annual weed suppression, and cash crop yield.

Materials and Methods

On going field experiments were started in 2003 at the Alabama Agricultural Experiment Station's E.V. Smith and Tennessee Valley Research and Extension Centers. In 2004, a similar experiment was also established at the University of Florida's West Florida Education and Research Center. The soils are Compass loamy sand, Decatur silty loam and Dothan sandy loam at E.V. Smith, Tennessee Valley and Jay Florida, respectively. The experimental design was a randomized complete block with three replicates having a split block restriction on randomization. Each plot had four rows of corn or cotton and both phases of the rotation were present each year.

The experiment involved two cover crops, rye preceding cotton and clover preceding corn rotated annually at each site. We examined five different planting dates and four different termination dates. Horizontal strips consisted of five cover planting dates and vertical strips consisted of four cover termination dates. Both covers were established with a no-till drill at 2 and 4 week prior to, 2 and 4 week after, and on the historical average first frost. The rye seeding rate was 100 kg/ha, and 56 kg of nitrogen (N) as ammonium nitrate was applied to rye in fall after establishment. The clover seeding rate was 28 kg/ha.

In the spring, covers were terminated at 4, 3, 2, and 1 week prior to cash crop planting with glyphosate at 1.12 kg ae/ha plus 2,4-D amine (0.20 kg ai/ha) utilizing a compressed CO_2 backpack sprayer delivering 140 L/ha at 147 kPa. Rye was flattened prior to glyphosate application with a mechanical roller-crimper to form a dense residue mat on the soil surface. Cover biomass from each plot was measured immediately before termination. The above-ground portion of rye and clover was clipped from one randomly-selected 0.25-m^2 section in each plot, dried at 60^0 C for 72 hours, and weighed.

The cotton varieties DP 444 BG/RR, ST 5242 BR and DP555BRR were planted at E.V. Smith, Tennessee Valley and Jay Florida, respectively. The corn variety Dekalb 69-72RR was planted at all the locations. Cash crops were planted with a four-row planter equipped with row cleaners and double-disk openers. Since both the E.V. Smith and West Florida sites had a well-developed hardpan, the experimental areas were in-row subsoiled prior to planting with a narrow-shanked parabolic subsoiler, equipped with pneumatic tires to close the subsoil channel. Weed biomass was determined in two 0.25-m^2 sections as described above when cotton reached the 4-leaf and corn reached 8-leaf growth stages. At this stage glyphosate was applied at 1.12 kg ae/ha. Plots were then kept weed-free until harvest utilizing Alabama Cooperative Extension System recommended herbicide applications. Though evaluations also included soil coverage by cover, cash crop stand establishment and height, and cash crop yield, in this paper we are only reporting the weed suppression provided by the two covers.

Table 1. Significance of environment [Experiment (location and years)], winter cover crop planting dates (PD) and termination dates (TD) on various parameters for corn and cotton.

		Cover		Weeds		Stand		Yield	
Effect	df	Corn	Cotton	Corn	Cotton	Corn	Cotton	Corn	Cotton
Exp	4	<0.001	<0.001	<0.001	0.003	0.098	<0.001	<0.001	<0.001
PD	4	<0.001	<0.001	> 0.15	<0.001	<0.001	<0.001	> 015	0.011
TD	3	0.015	<0.001	0.094	<0.001	> 0.15	> 0.15	<0.001	0.010
Exp*PD	16	<0.001	<0.001	0.088	<0.001	0.133	<0.001	0.007	0.137
Exp*TD	12	> 0.15	<0.001	> 0.15	<0.001	0.006	0.127	> 0.15	> 0.15
PD*TD	12	> 0.15	0.003	> 0.15	> 0.15	> 0.15	> 0.15	> 0.15	> 0.15
Exp*PD*TD	48	> 0.15	> 0.15	> 0.15	> 0.15	> 0.15	> 0.15	> 0.15	> 0.15

Fixed effects and interactions were considered different if P>F was equal to or less than 0.1

Data were analyzed by analysis of variance using mixed model methodology as implemented in SAS Proc Mixed. Experiment (year and location), planting and termination dates were considered the fixed effects. The significance of treatments and treatment combinations can be found in Table 1. Only the results of significant interactions are discussed in this paper.

Results and Discussion

Significant difference in the clover biomass was observed across planting dates when averaged over the termination dates in all the experiments. With the four week delay in planting clover biomass was reduced by more than half in all experiments except at EVS in 2004. At both EVS(2004) and JAY(2005) the two week delay in planting resulted in stimulation of clover biomass production. Clover however suffered severe winter damage at TVS in 2004 and the biomass production was significantly low compared to the other locations and years (Fig 1).

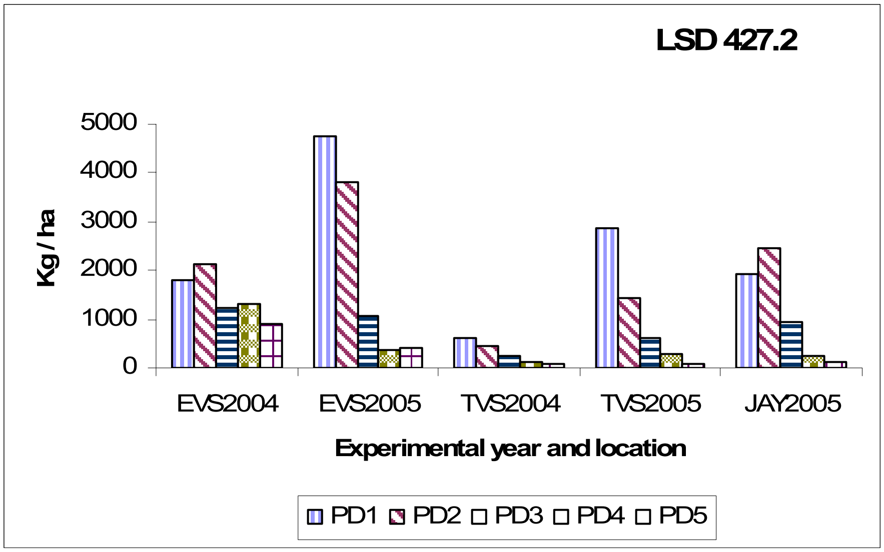


Figure 1: Effect of winter cover crop planting dates on clover biomass (kg/ha) for each location and year.

The four week delay in rye planting was not as detrimental in biomass production as was in case of clover when averaged over the termination dates. Biomass production was impacted more when the planting was delayed by six weeks (Fig 2). When averaged over the planting dates, rye biomass increased with the delayed termination. However, at EVS in both the years and at TVS in 2004, the difference in the biomass produced at the first three termination dates was not as significant as it was in other two experiments (Fig 3). The maximum biomass for rye was produced when rye was planted four weeks prior to average first frost and terminated two weeks prior to cotton planting (Table 2).

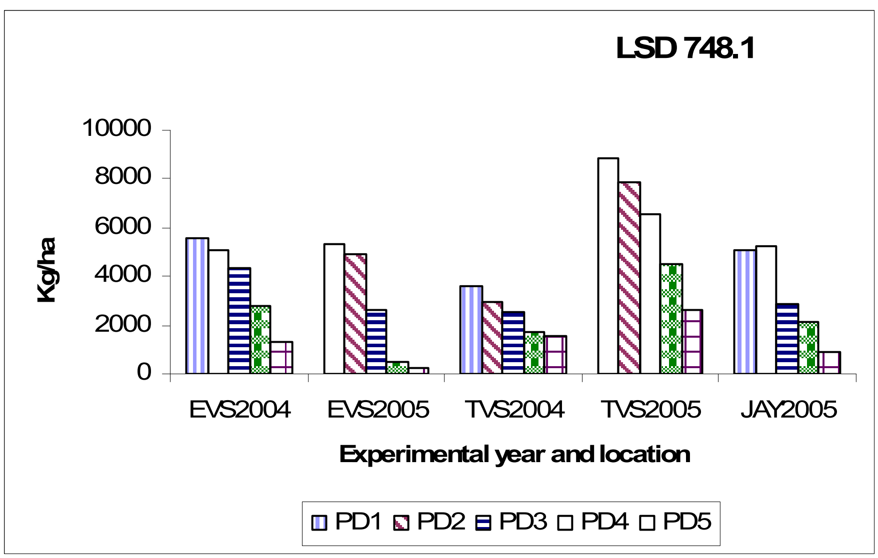


Figure 2: Effect of winter cover crop planting dates on rye biomass (kg/ha) for each location and year.

Table 2. Effect of planting dates (PD) and termination dates (TD) on rye and weed biomass (kg/ha) in cotton.

	PD1		PD2		PD3		PD4		PD5	
	Rye	Weeds	Rye	Weeds	Rye	Weeds	Rye	Weeds	Rye	Weeds
TD1	4043	371	3237	367	2465	553	1516	519	795	556
TD2	5737	149	5045	193	3782	336	2205	303	1190	591
TD3	6745	78	6433	162	4266	257	2403	221	1290	366
TD4	6229	57	6094	67	4655	190	3165	191	2002	293

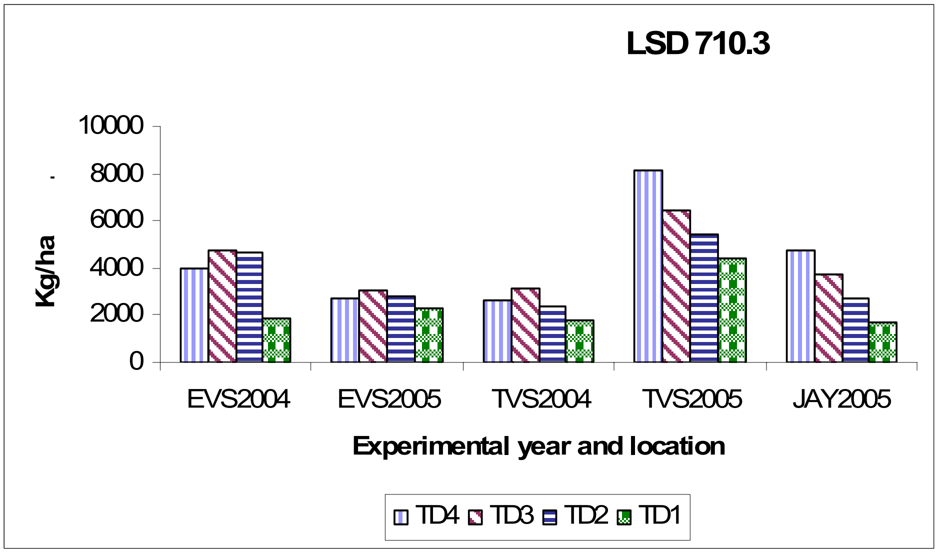


Figure 3: Effect of winter cover crop termination dates on rye biomass (kg/ha) for each location and year.

Significant experiment by winter cover crop planting date and experiment by winter cover crop termination date interaction was observed for weed biomass in cotton (Table 1). The delay in planting rye always resulted in more weed biomass in all experiments. The four week delay in planting rye was observed to be more critical in weed control except at EVS and JAY in the first year of the experiment. In both these experiments weed populations were significantly high when rye was planted four weeks after average first frost (Fig. 4). When averaged over the planting dates, at EVS the delayed cover termination gave better weed control, in other experiments the control was better when rye was terminated three weeks prior to cotton planting (Fig 5).

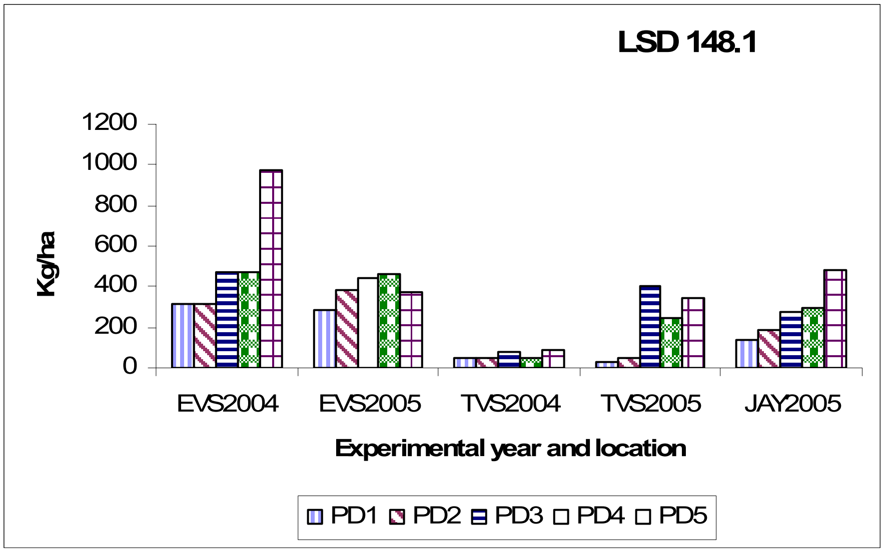


Figure 4: Effect of winter cover crop planting dates on weed biomass (kg/ha) in cotton for each location and year.

Table 3. Effect of planting dates (PD) and termination dates (TD) on clover and weed biomass (kg/ha) in corn.

	PD1		PD2		PD3		PD4		PD5	
	Clover	Weeds	Clover	Weeds	Clover	Weeds	Clover	Weeds	Clover	Weeds
TD1	2364	65	1514	101	518	105	378	84	373	158
TD2	2412	37	2099	91	711	143	205	133	230	98
TD3	2329	40	2018	56	1124	124	473	82	182	93
TD4	2453	36	2637	59	898	95	823	134	522	132

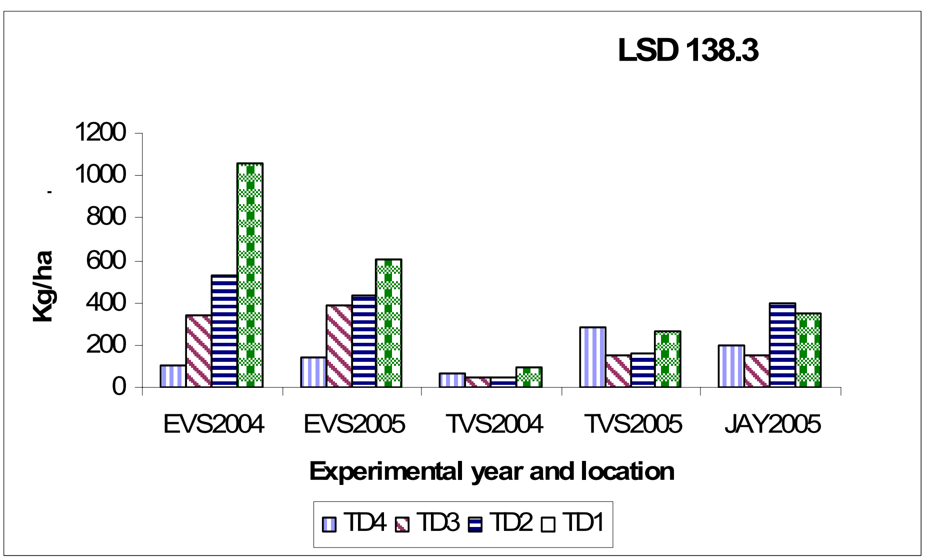


Figure 5: Effect of winter cover crop termination dates on weed biomass (kg/ha) in cotton for each location and year.

The weed control in corn was not as predictable (Fig 6) as it was in case of cotton only the experiment by harvesting date interaction was significant in this case. The weed populations, however, were significantly low in the corn. The least weed biomass observed was 36 kg/ha corresponding to the clover biomass of 2453 kg/ha and highest was 158 kg/ha corresponding to clover biomass of 373 kg/ha. This is likely due to the earlier sampling time in corn when fewer summer annual weeds have emerged. Our observations of decrease in weed biomass by corresponding increase in cover crop biomass agree with other research findings (Teasdale et al 1991). Yenish et al. (1996) also reported better early season weed control by crimson clover than rye in no till system.

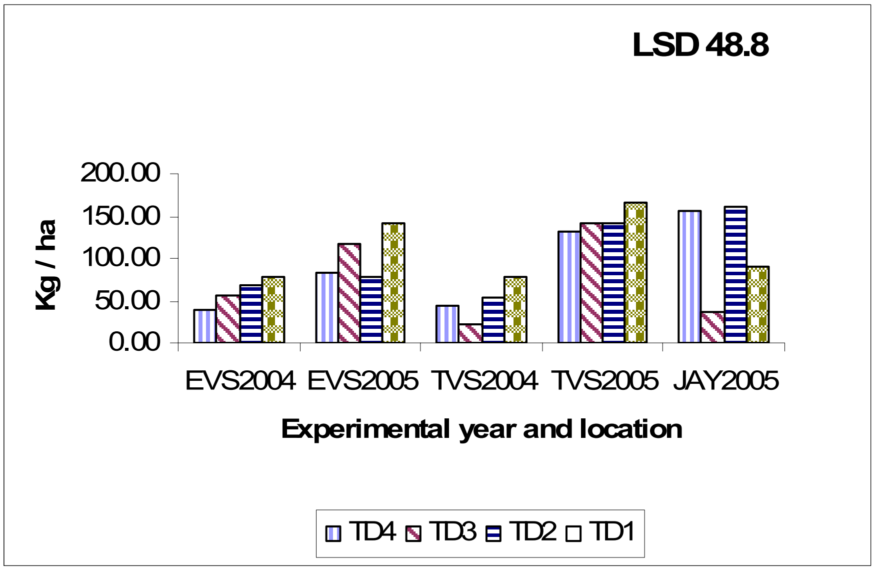
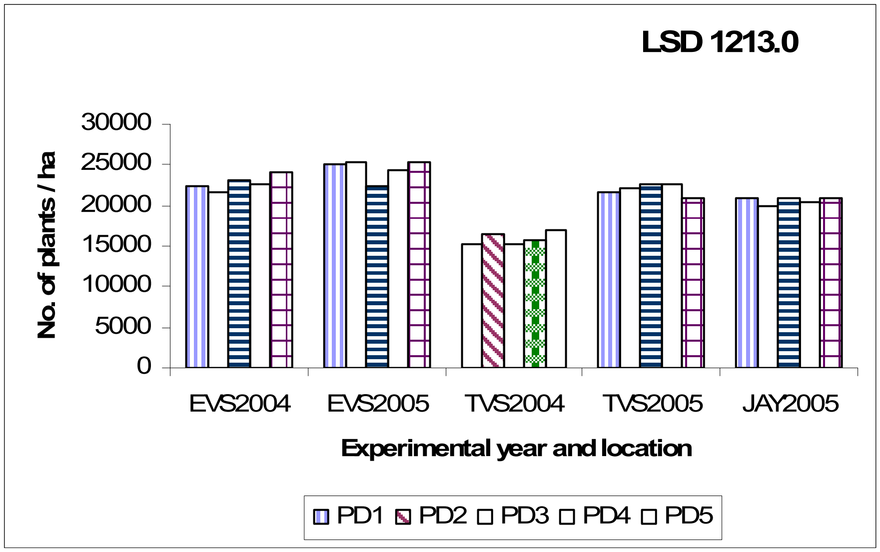


Figure 6: Effect of winter cover crop planting dates on weed biomass (kg/ha) in corn for each location and year.

None of the winter cover crop planting or winter cover crop termination dates had any effect on the establishment of the two cash crops through the heavy residue except at TV in 2005 where the more cotton stands were found in the plots with later planting dates (Fig 7-8). As the cash crop stands were not affected by the presence of the heavy winter cover crop residue on plots with earlier planting and later termination dates, thus there was no significant difference in the cotton lint and corn grain yields (Fig 9-10).



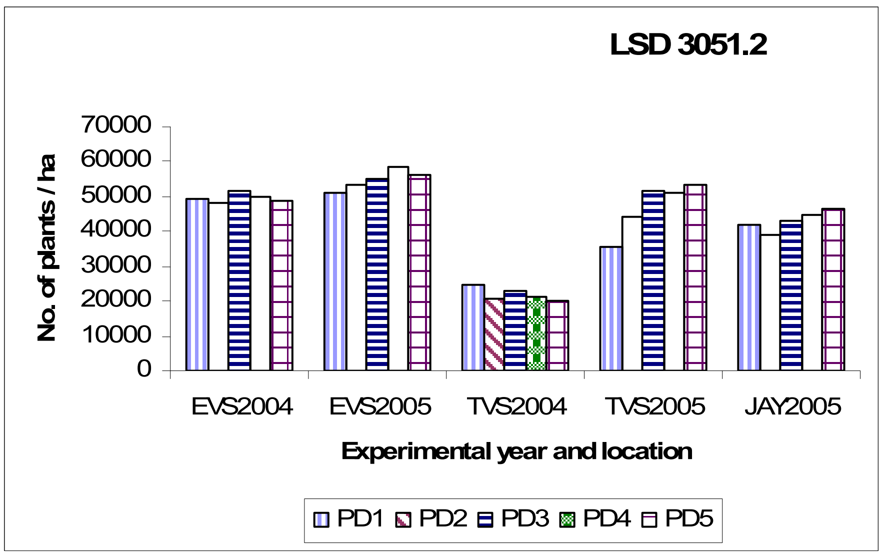
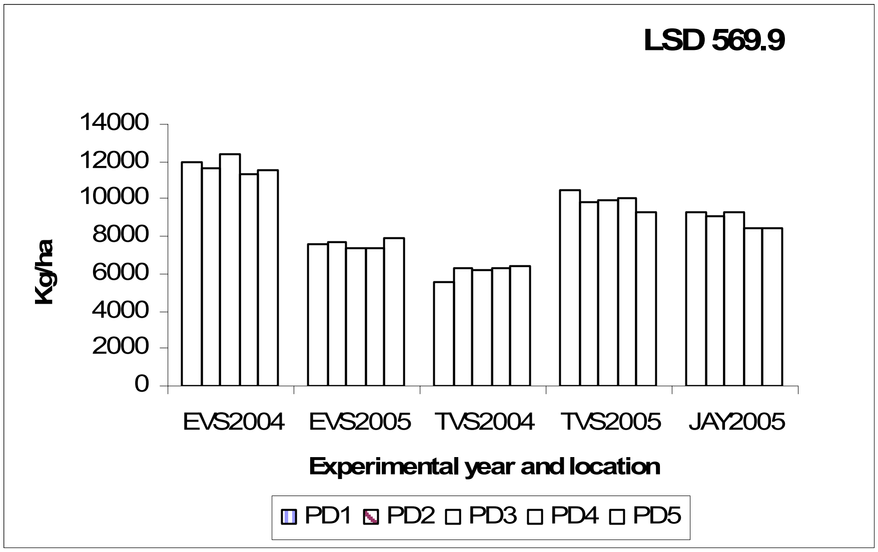


Figure (7-8): Effect of winter cover crop planting dates on corn and cotton populations, respectively, for each location and year.



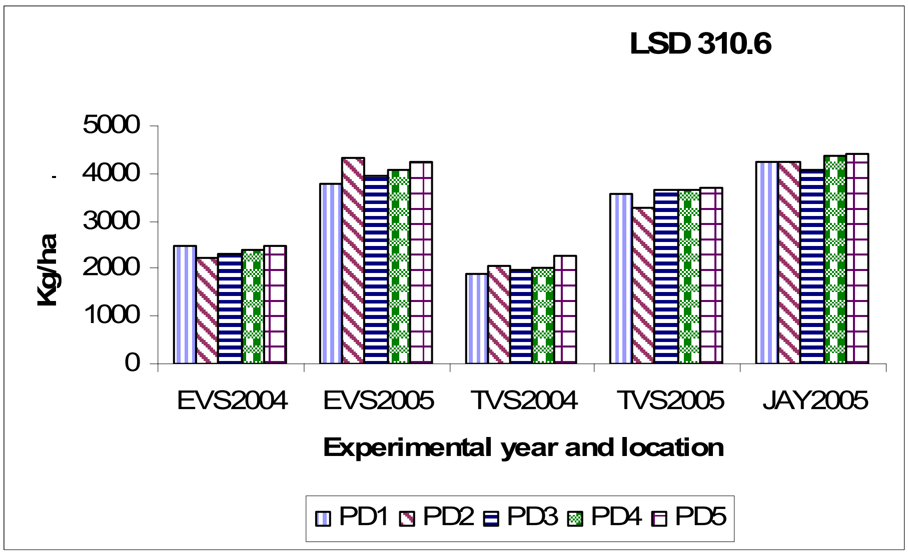


Figure (9-10): Represent the effect of planting dates on corn (kg/ha) and cotton lint yield (kg/ha) respectively across all experiments.

Conclusions

In general, winter cover crop biomass increased with the earlier planting and later termination and weed biomass decreased with increasing biomass. Observations indicate that high cover biomass should decrease early season weed interference and facilitate flexibility of POST application timing.

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