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Exhausting weed seed bank before sowing through stale seedbed technique for managing weeds in winter irrigated *Bt* cotton (*Gossypium hirsutum*) based intercropping system

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ABSTRACT : A new method of introducing short duration less aggressive weed smothering intercrop which could complete the life cycle within 40 - 45 DAS without sacrificing the main crop population was standardized. Weed control under intercropping system is cumbersome and the removal of weeds by manual method is tedious as it is very difficult to differentiate the young weed seedlings and germinating intercrops. Hence, a novel approach of exhausting weed seed bank before the crop emergence by stale seed bed approach was standardized for *Bt* cotton based intercropping system during 2010-2011 and 2011-2012 cropping season at Regional station of Central Institute for Cotton Research, Coimbatore. Among the treatments, Stale Seed Bed Technique (SSBT) using a mixture of pendimethalin 1.0 kg + glyphosate 1.0 kg one week after pre sowing irrigation (one week before sowing) recorded the highest weed control efficiency of 85.2 per cent on 35- 40 DAS. Adopting this new method of planting, *Bt* cotton RCH 20 *Bt* with coriander as intercrop under SSBT method of managing weeds with pendimethalin 1.0 kg + glyphosate 1.0 kg recorded the highest seed cotton yield (3261 kg/ha) and seed cotton equivalent yield (4686 kg/ha) .

Key words : Incremental cost, seed cotton equivalent yield, seed cotton yield, stale seed bed technique, weed control efficiency

Cotton is sensitive to weed competition due to its slow initial growth and wider spacing. In recent years, Bt cotton which is high yielding and responsive to higher levels of inputs like fertilizers, irrigation etc., is grown under intensive cropping system, all these factors promote luxurious growth of weeds which grow more quickly than cotton and compete strongly for soil moisture, nutrients, light and space. Reduced yield due to weeds to an extent of 60 per cent (Sadangi and Barik,2007) has been reported. Present recommendation of pre emergence herbicide (pendimethalin) application followed by two or three inter cultivation is a common practice (Prabhu *et al.,* 2010). However, providing timely weed control may not be possible as inter-row cultivation is weather dependent, in case of heavy rains, the soils become sticky and wet and trafficability is poor while in the dry soil, the surface becomes hard making inter row cultivation difficult and also many times, non availability of human labourers for weeding makes timely weed control as impossible and costly affair. Weed control under intercropping system is all the more difficult because the removal of weeds by manual method is tedious as it is very difficult to differentiate the young weeds seedlings and germinating intercrops and as a result, the required population of intercrops could not be maintained due to manual removal of seedlings of intercrops unknowingly. Hence, a novel approach of exhausting weed seed bank before the crop emergence by stale seed bed (SSBT) approach without sacrificing the cotton population has been attempted to explore the practical feasibility of stale seed bed technique in *Bt* cotton based intercropping system. A stale seed bed is a seedbed which has been prepared and given a false start some weeks before the seed is due to be sown, any weed seeds in the bed will be encouraged to grow so that they can be raked out and killed before the actual cotton

crop is sown. This technique reduces the number of weeds which have to be controlled when the cotton seedlings start to grow in the field. Stale seedbeds are established several weeks or months before planting.

MATERIALS AND METHODS

Field experiments were conducted during winter (August – February) of 2010-2011 and 2011-2012 cropping season under irrigated condition in the main farm of Regional station, Central Institute for Cotton Research, Coimbatore. Normally cotton crop is grown under ridges and furrow method with sowing of cotton in one side of the ridge and the other side is kept vacant. We have introduced short duration, less aggressive weed smothering intercrop, coriander cv surabhi (which completes its life cycle within 40 - 45 DAS and its leaves utilized for culinary purpose) on the other side of ridges so that the cotton crop population not sacrificed. The hirsutum based cotton hybrid cv RCH 20 *Bt* has been evaluated at 90x60cm.The seed beds were prepared two weeks in advance of sowing and for stale seed bed technique, irrigation was given immediately after the seed bed preparation and after receiving the moisture, weed seeds were tempted to germinate and targeted by the weed control treatments. Six weed control treatments were evaluated in randomized block design with four replications. The treatments were, W1-Weed control by stale seed bed technique (SSBT) using glyphosate 1.0 kg (spraying of glyphosate once one week after the pre sowing first irrigation) followed by hand weeding 35- 40 DAS, W2-Weed control by SSBT using pendimethalin 1.5 kg/ha (herbicide spraying on 3rd day after pre sowing first irrigation) followed by hand weeding 35- 40 DAS, W3 - Weed control by SSBT using glyphosate 1.0 kg + pendimethalin 1.0 kg (spraying of herbicide mixture once ,week after the pre sowing first irrigation) followed by hand weeding 35- 40 DAS, W4-Pre emergence weed control using pendimethalin 1.5 kg on 3rd day of cotton sowing followed by hand weeding at 35- 40 DAS, W5- Removal of germinated weeds , a week after pre sowing first irrigation manually by scrapping the top layer of soil using hand hoe followed by hand weeding at 15-20 DAS and 35- 40 DAS, W6- Un weeded check. The soil of the experimental fields was low in nitrogen (168.0, 168.0 kg/ha), high in phosphorus (29, 28.5 kg/ha) and potassium (557, 590 kg/ha) in the first and second year of experimentation respectively. The results of both the years of experimentation has shown the same trend and hence the data of two years were pooled and analysed using standard analysis of variance. The significance of the difference between means of two treatments was tested using least significance (LSD) at 5 per cent probability level. The data on weed count was subjected to square root transformation before statistical analysis to normalize their distribution (Panse and Skhatme,1978).

RESULTS AND DISCUSSION

Weed flora of the experimental field : The experimental field had 29 broad leaved weeds, seven grass weeds, and a lone sedge weed. The broad leaved weeds were**,** *Abutilon indicum, Acalypha indica, Amaranthus spinosus, Amaranthus viridis,Amaranthus polygamus, Argemone mexicana, Boerhaavia erecta, Boerhaavia diffusa, Coccinia indica, Convolvulus arvensis, Corchorus trilocularis, Celosia argentea,Croton sparsiflorus, Datura fastuosa, Digera arvensis, Euphorbia hirta, Indigofera ennaphylla, Leucas urticaefolia,Malvastrum coromandelianum, Oldenlandia umbellate, Parthenium hysterophorus, Phyllanthus maderaspatensis, Phyllanthus niruri, Portulaca oleracea, Priva leptostachya, Sonchus oleraceus, Trianthema portulacastrum, Tridax procumbens* and *Vicoa indica.* The grassy weeds *viz., Chloris barbata, Cynodon dactylon, Dinebra*

Table 1. Weed control treatments on weed count, weed dry matter production and weed control efficiency of *Bt* cotton + coriander system

Weed control treatments	Weed count * 35- 40 DAS	Weed DMP g/m^2 35- 40 DAS	Weed control efficiency (%) (%) 35- 40 DAS
W1- SSBT glyphosate 1.0 kg – HW (35-40 DAS)	132.3 (11.50)	54.4	54.1
W2- SSBT pendimethalin 1.5 kg- HW (35-40 DAS)	40.6 (6.37)	21.5	81.9
W3- SSBT pendimethalin 1.0 kg + glyphosate 1.0 kg - HW(35-40 DAS)	30.9 (5.56)	17.6	85.2
W4 – Pre emergence weed control with pendimethalin 1.5 kg - HW(35-40 DAS)	53.59 (7.32)	30.5	74.4
W5 – SSBT and manual removal of weeds (thrice , week before sowing, 15-20 DAS and 35-40 DAS)	44.95 (6.71)	29.9	74.8
W6- Unweeded control	555.25 (15.97)	118.5	-
CD (P=0.05)	0.56	4.67	

*Figures in parenthesis are square root transformed values for statistical analysis

Arabica, Eleusine aegyptiaca, Panicum colonum, Panicum repens, Pennisetum cenchroides, Sporobolus scabrifolius and the lone sedge weed, *Cyperus rotuntus* were present in the experimental field. Among the weed species, The carpet weed, Trianthema *portulacastrum* was the most dominant weed flora during initial stage of cotton growth.

Weed control treatments on weeds associated with *Bt* cotton + coriander system : The weed count recorded on 35- 40 DAS (Table 1) has shown significant differences and among the treatments, stale seed bed application of glyphosate 1.0 kg + pendimethalin 1.0 kg one week before sowing recorded the lowest weed count and this might be due to efficient control of germinated small weeds by glyphosate and the germinating weeds by the residual action of pendimethalin. Stale seed bed technique and application of glyphosate alone could not control the weeds efficiently because all the weeds did not germinate in a week time after irrigation and the glyphosate could kill only the germinated weeds and not the weeds germinating after the glyphosate spraying. The dry matter production of weeds ranged from 17.6 g/m^2 to 118.5 g/m^2. The weed dry matter accumulation followed the same trend as that of weed count. The weed control efficiency ranged from 54.1 to 85.2 per cent and the highest weed control efficiency was being achieved by SSBT and application of a combination of glyphosate 1.0 kg and pendimethalin 1.0 kg/ha.

Weed control treatments on nutrient depletion by weeds : Weeds compete with cotton severely for growth factor during early stages.

Table 2. Nutrient depletion by weeds associated with cotton cultivation as influenced by weed control treatments

Weed control treatments	Nutrient depletion by weeds (kg/ha) 35- 40 DAS		
	N	P	K
W1- SSBT glyphosate 1.0 kg – HW (35- 40 DAS)	16.4	5.1	19.1
W2- SSBT pendimethalin 1.5 kg- HW (35- 40 DAS)	7.1	2.3	7.3
W3- SSBT pendimethalin 1.0 kg + glyphosate 1.0 kg - HW(35-40 DAS)	6.3	1.8	6.4
W4 – Pre emergence weed control with pendimethalin 1.5 kg - HW(35-40 DAS)	10.8	2.9	11.2
W5 – SSBT and manual removal of weeds (thrice , week before sowing, 15-20 DAS and 35- 40 DAS)	10.3	2.9	10.5
W6- Unweeded control	33.2	9.8	35.9
CD (p=0.05)	1.27	0.15	1.29

The nutrient depletion by weeds ranged from 6.3 to 33.2 kg N, 1.8 to 9.8 kg/ha P and 6.4 to 35.9 kg/ha K during 35- 40 DAS (Table 3) and the highest depletion being recorded under the unweeded check and the lowest under SSBT of pendimethalin + glyphosate treated plot due to better weed control achieved with the combination of residual and translocated herbicide. Singh *et al.*, 2013 reported that weeds removed 5 - 6 times of nitrogen, 5 - 12 times of phosphorus and 2 -5 times of potash of that of cotton crop at early stages.

Weed control treatments on seed cotton yield, intercrop yield and incremental cost of *Bt* cotton + coriander system Seed cotton yield : The seed cotton yield was significantly influenced by the weed control treatments. The highest seed cotton yield of 3261 kg/ha was achieved by SSBT of pendimethalin 1.0 kg + glyphosate 1.0 kg + one hand weeding (35- 40 DAS) and was on par with SSBT application of pendimethalin 1.5 kg + hand weeding 35- 40 DAS and SSBT and manual removal of weeds (thrice). However SSBT and application of glyphosate alone could not produce the desired result as the weed seed germination is a staggered process and application of glyphosate alone could target only the germinated weeds and the weed which are germinating after the herbicide spray could not be targeted and hence a lot of weeds were left uncontrolled which might have competed with cotton crop causing significant yield loss. All the treatments under SSBT method except glyphosate with one hand weeding were found significantly superior to normal method of pre emergence application on third day of cotton sowing. Sanbagavalli *et al.,* 2009 obtained better weed control and highest seed cotton yield with stale seed bed technique and application of glyphosate 2.0 kg/ha before sowing followed by two manual weed control.

Intercrop yield : The yield of intercrop also significantly influenced by the weed control treatments. The unweeded treatments recorded the lowest (0.73 t/ha) of coriander and this was due to smothering of coriander by uncontrolled weeds. Among the treatments, SSBT and application of mixture of pendimethalin 1.0 kg and glyphosate 1.0 kg , SSBT application of pendimethalin 1.5 kg recorded higher inter crop yield. While, the normal method of pre emergence application of pendimethalin 1.5 kg on third day of cotton sowing recorded a reduction of about 1.31 t/ha in intercrop yield and this reduction

Table 3. Weed control treatments on seed cotton yield, intercrop yield, seed cotton equivalent yield and incremental cost of Bt cotton + coriander system (pooled mean)

Weed control treatments	Seed cotton yield (kg/ha)	Yield of intercrop (t/ha)	Seed cotton equivalent yield (kg/ha)*	Cost of weeding (Rs/ha)
W1- SSBT glyphosate 1.0 kg - HW(35- 40 DAS)	1879	2.65	2428	3909
W2- SSBT pendimethalin 1.5 kg- HW(35- 40 DAS)	3080	6.45	4448	4970
W3- SSBT pendimethalin 1.0 kg + glyphosate 1.0 kg - HW(35- 40 DAS)	3261	6.70	4687	5388
W4 – Pre emergence weed control with pendimethalin 1.5 kg – HW (35- 40 DAS)	2852	5.39	4004	4970
W5 – SSBT and manual removal of weeds (thrice , week before sowing, 15-20 DAS and 35- 40 DAS)	3190	5.35	4325	9000
W6- Unweeded control	630	0.73	778	-
CD (p=0.05)	262.1			

*A total cost of 1750 incurred towards coriander intercropping

might be due to sensitivity of intercrop coriander for the dose tested as pre emergence spray on third day of sowing (cotton and coriander sowing done on the same day) since the herbicide spraying was done on third day of sowing. However under stale seed bed technique, as the herbicide spraying has been advanced by7-10 days of sowing, the herbicidal toxicity might be lesser on the intercrop and resulted in higher biomass of coriander. SSBT and manual removal of weeds also recorded a reduction in intercrop yield to the tune of 1.35 t/ha than SSBT and application of pendimethalin + glyphosate. This might be due to removal of coriander seedlings unknowingly while weeding as it was very difficult to differentiate the young intercrop seedlings with other young weeds.

Seed Cotton equivalent yield and Incremental cost : The seed cotton equivalent yield has been worked out equating the value of intercrop in terms of cotton. The highest seed cotton yield of 4687 kg/ha has been recorded under SSBT application of pendimethalin1.0 kg + glyphosate 1.0 kg with one hand weeding at 35- 40 DAS. This was closely followed by SSBT application of pendimethalin 1.5 kg + one hand weeding at 35- 40 DAS and SSBT with manual removal of weeds thrice. The incremental cost due to weeding ranged from 3905 to 9000 and the manual method of weed control involved the highest cost of weeding as compared to integrated method of weed control.

From the above studies it is concluded that inclusion of short duration, less aggressive weed smothering crop like coriander as intercrop with Bt cotton by adopting this new method of planting and managing weeds by stale seed bed technique is feasible and efficient than existing method.

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