CHAPTER-VI

SUMMARY AND CONCLUSION
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The investigation entitled “Integrated weed management in hybrid cotton with legume intercrop under rainfed upland ecosystem of Orissa” was conducted during the warm-wet (kharif) season of the year 2010 and 2011 in the Research Farm of the All India Coordinated Cotton Improvement Project under the Regional Research and Technology Transfer Station (OUAT), Bhubanipatna, Odisha. The soil of the experimental site was clay-loam in texture (sand -36.42 %, silt - 23.87 and clay-39.71%), medium in organic carbon (0.72 %), low in available N (175.9 kg ha\(^{-1}\)), medium in available P (36.7 kg ha\(^{-1}\)) and medium in available K (243.6 kg ha\(^{-1}\)) and slightly acidic in reaction (pH-6.1). The experiment was laid out in Factorial Randomised Block Design (FRBD) with three replications and twenty treatment combinations consisting of four intercropping systems and five weed management practices. The intercropping systems were sole cotton (SC), cotton + soybean (C + S), cotton + cowpea (C + C) and cotton + black gram (C + BG). The weed management practices included pre-em pendimethalin @ 1.0 kg ha\(^{-1}\) at 1 DAS (Pendi), straw mulching of 10 cm thick at 1 DAS (SM), pre-em pendimethalin @ 1.0 kg ha\(^{-1}\) at 1 DAS + straw mulching of 10 cm thick at 30 DAS (Pendi + SM), hand weeding twice at 30 and 50 DAS (HW) and unweeded control (UC). Cotton hybrid Bunny was sown with a spacing of 90 cm x 60 cm. The intercrops like cowpea (cv- Utkal Manika), soybean (cv- Jawahar Soybean) and black gram (cv- Ujala) were sown in lines on the same day in the inter-row spaces of cotton with a spacing of 30 cm x 10 cm in North-South row direction. Weed management treatments were applied as per schedule along with other agronomic and plant protection practices. Different biometric observations were recorded on the main crop and intercrops. The results of the investigation have been summarised hereunder.
6.1 Floristic composition of weeds

The weed flora of the experimental field consisted of eight species of grasses, two species of sedges and twenty three species of broad leaved weeds. Broad leaves (52.3%) dominated grasses (25.2 %) and sedges (22.5%).

6.2 Intercropping systems

6.2.1 Cotton + black gram (C + BG) intercropping system significantly reduced the grasses, sedges, broad leaves and the total weed population to the lowest from 30 to 90 DAS. The total weed dry weight was significantly the lowest during the period in this system and hence, registered the highest WCE as well as the lowest quantity of N, P and K removal by weeds.

This system recorded significantly the highest plant height, canopy diameter and dry matter of cotton from 30 to 120 DAS and registered the maximum uptake of N, P and K by cotton crop at 120 DAS. The CGR and RGR were significantly the highest in this system between 30-60 DAS, 60-90 DAS and 90-120 DAS and it ranked top in LAI at different dates of observation.

C + BG intercropping system recorded significantly the highest number of sympodial branches plant\(^{-1}\), bolls plant\(^{-1}\), bolls m\(^{-2}\), the highest boll setting percentage, boll weight, ginning percentage, LI, SI, SCY, LY, CEY, gross return, net return, B: C ratio and the lowest WI. It ranked 2\(^{nd}\) in number of fruiting points plant\(^{-1}\).

This intercropping system could be considered appropriate for the locality from both weed suppression and economic point of view.

6.2.2 Cotton + soybean (C + S) intercropping system ranked 3\(^{rd}\) in reducing weed density from 30 to 90 DAS and occupied 2\(^{nd}\) position in weed dry weight, WCE and nutrient removal from the soil by weeds.

C + S recorded the 3\(^{rd}\) tallest cotton plants at early stage (at 30 and 60 DAS) and 2\(^{nd}\) best tall plants at 90 and 120 DAS and ranked 2\(^{nd}\) in wider canopy throughout
the crop duration except at 60 DAS when it stood 3rd. The highest cotton plant dry
matter of was in this system at 120 DAS, whereas, it ranked differently at different
dates of observation. This system ranked 1st in N and K uptake and 3rd in P mining. It
held the 3rd rank between 30-60 DAS and 2nd between both 60-90 and 90-120 DAS in
CGR. The RGR was the 2nd highest between 30-60 DAS and 90-120 DAS and 3rd
between 60-90 DAS. It ranked 2nd in LAI at different dates of observation.

C + S occupied the 1st position in number of fruiting points plant⁻¹, boll weight
(at par with C + BG) and cost of cultivation. It was the 2nd best intercropping system
with respect to sympodial branches plant⁻¹, bolls plant⁻¹, bolls m⁻², SCY, LY, CEY, WI,
gross return, net return and B: C ratio. It ranked 3rd in boll setting percentage, ginning
percentage, SI and LI.

This is the 2nd best system and could be adopted in the cotton growing areas of
Odisha.

6.2.3 Cotton + cowpea (C + C) intercropping system had the 2nd position in
reducing weed density at 30, 60 and 90 DAS, weed dry weight and removal of
nutrients from the soil by weeds and 3rd rank in WCE.

C + C recorded the 2nd tallest cotton plants at 30 and 60 DAS and 3rd tallest
plants at 90 and 120 DAS. It ranked the 2nd in canopy diameter at all the dates of
observation except at 90 DAS when it stood 3rd. The lowest dry matter of cotton plant
was at 120 DAS, whereas, it ranked 2nd at 30, 60 and 90 DAS. This system was the 1st
with respect to N uptake, 2nd in P uptake and 3rd in K uptake. It held the 2nd rank
between 30-60 DAS and 3rd between both 60-90 and 90-120 DAS in CGR. The RGR
was the 3rd highest between 30-60 DAS and 90-120 DAS and 2nd between 60-90
DAS. It ranked 4th in LAI at 30 and 120 DAS, 2nd at 60 DAS and 3rd at 90 DAS.

C + C was the 2nd best intercropping system in boll setting percentage, boll
weight, SI and LI. It held 3rd rank in number of fruiting points plant⁻¹, ginning
percentage, LY, CEY, WI, gross return, net return and B: C ratio. This system occupied 4th position in sympodial branches plant\(^{-1}\), bolls plant\(^{-1}\), bolls m\(^{-2}\) and SEY.

This system could also be considered for adoption with suitable bushy type of varieties recommended for cultivation during the *kharif* season.

**6.2.4 Sole cotton (SC)** recorded the highest weed density and the lowest WCE. It was statistically at par with C + C with respect to weed dry weight and removal of nutrients by weeds.

The shortest cotton plants were with SC at 30, 60 and 120 DAS, whereas, it was the 3rd highest at 90 DAS. It registered wider canopy at 120 DAS while ranked 3rd at 30 and 90 DAS and 4th at 60 DAS. The lowest dry matter of cotton was at 60 DAS, whereas, it ranked 3rd at 30, 90 and 120 DAS.

SC recorded the 2nd highest number of fruiting points plant\(^{-1}\), ranked 3rd in sympodial branches plant\(^{-1}\), bolls plant\(^{-1}\), bolls m\(^{-2}\), boll weight, SCY and LY. This system ranked 4th in boll setting percentage, ginning percentage, SI, LI, CEY, WI, gross return, net return and B: C ratio.

From weed management and economic viewpoints, sole cotton cultivation could not be recommended for the farmers of the rainfed upland ecosystems of Odisha.

**6.3 Weed management practices**

**6.3.1 Pre-em application of pendimethalin @ 1.0 kg ha\(^{-1}\) with straw mulching at 30 DAS (Pendi + SM)** was the best treatment recording significantly the minimum density of grasses, sedges, broad leaves and total weeds; total dry weight of weeds and WCE at 30 DAS. But, it ranked 2nd at 60 and 90 DAS in WCE. The 2nd lowest removal of N and K by weeds was in this treatment.
This integrated approach of Pendi + SM ranked 1\textsuperscript{st} in plant height at 30 and 120 DAS and ranked 2\textsuperscript{nd} at 60 and 90 DAS. This had the widest canopy of cotton at 30 and 120 DAS and ranked 2\textsuperscript{nd} at 60 DAS while 3\textsuperscript{rd} at 90 DAS. It held the top rank in producing dry matter of cotton at all the dates of observation and uptake of N, P and K at 120 DAS. The CGR was the highest between 60-90 and 90-120 DAS, whereas, it was the 2\textsuperscript{nd} highest between 30-60 DAS. It also registered the highest LAI and RGR at all dates of observation.

Pendi + SM ranked top with respect to all the yield attributing and quality characters of cotton like sympodial branches plant\textsuperscript{-1}, fruiting points plant\textsuperscript{-1}, bolls plant\textsuperscript{-1}, bolls m\textsuperscript{-2}, boll setting percentage, boll weight, ginning percentage, LI, SI, SCY, LY, CEY, WI, gross return, net return and B: C ratio.

This integrated approach could be adopted for cotton in this region for efficient weed management and greater profitability.

6.3.2 Pre-em application of pendimethalin @ 1.0 kg ha\textsuperscript{-1} (Pendi) was at par with Pendi + SM in reducing grasses, stood 3\textsuperscript{rd} in sedges and 2\textsuperscript{nd} in broad leaves and total weed density at 30 DAS. At 60 DAS, it was the 3rd best in reducing grasses and sedges and 4\textsuperscript{th} in both broad leaves and total weed population. It ranked the 3\textsuperscript{rd} in managing all types of weeds at 90 DAS. With respect to weed dry weight reduction, this treatment was 3\textsuperscript{rd} at 30 and 90 DAS and 4\textsuperscript{th} at 60 DAS. It recorded the 3\textsuperscript{rd} WCE at 30 DAS and 4\textsuperscript{th} at 60 and 90 DAS. It was the 3\textsuperscript{rd} best treatment with respect to removal of N, P and K by weeds.

Pendi alone held the 2\textsuperscript{nd} rank at 30 DAS and 3\textsuperscript{rd} at 60, 90 and 120 DAS with respect to plant height. Canopy diameter was the 2\textsuperscript{nd} at 30 and 90 DAS and the 3\textsuperscript{rd} at 60 and 120 DAS. This was the 2\textsuperscript{nd} best treatment at 30, 60 and 90 DAS and the 3\textsuperscript{rd} at 120 DAS in dry matter production of cotton. It occupied the 3\textsuperscript{rd} position in uptake of N and K but 4\textsuperscript{th} position in P. CGR was the 2\textsuperscript{nd} at 60 DAS and 3\textsuperscript{rd} at 30 and 90 DAS. It ranked 2\textsuperscript{nd} in LAI at 30, 60 and 120 DAS, but 3\textsuperscript{rd} at 90 DAS. RGR was the 2\textsuperscript{nd} between 60-90 DAS and 3\textsuperscript{rd} between 30-60 and 90-120 DAS.
This treatment held the 2\textsuperscript{nd} rank in number of fruiting points plant\textsuperscript{-1}, ginning percentage, LI and B: C ratio. It occupied the 3\textsuperscript{rd} position with respect to bolls plant\textsuperscript{-1}, bolls m\textsuperscript{-2}, boll setting percentage, boll weight, SI, SCY, LY, CEY, WI, gross return and net return and 4\textsuperscript{th} position in number of sympodial branches plant\textsuperscript{-1}.

This treatment could be well accepted and adopted in areas where mechanical weed management is not feasible due to incessant rains and unavailability of labourers. It should be followed by one mechanical weeding or post-em herbicide for better results.

6.3.3 The treatment with 10 cm thick straw mulching at 1 DAS (SM) was equally effective as Pendi + SM and Pendi alone in reducing grasses and was the 2\textsuperscript{nd} best treatment with respect to sedges, BLW and total weed population at 30 DAS. It was 2\textsuperscript{nd} in reducing grasses, 4\textsuperscript{th} in sedges and 3\textsuperscript{rd} in both BLW and total weed density at 60 DAS. It ranked 3\textsuperscript{rd} in managing all types of weeds at 90 DAS. This treatment was 2\textsuperscript{nd} in reducing weed dry weight at 30 DAS and 3\textsuperscript{rd} at 60 and 90 DAS. It recorded the 2\textsuperscript{nd} highest WCE at 30 DAS and the 3\textsuperscript{rd} rank at 60 and 90 DAS. It was 2\textsuperscript{nd} best with respect to removal of N and P and 3\textsuperscript{rd} in K by weeds.

SM occupied the 3\textsuperscript{rd} position in plant height and canopy diameter at 30 DAS and 4\textsuperscript{th} position at 60, 90 and 120 DAS. It ranked 2\textsuperscript{nd} at 120 DAS, 3\textsuperscript{rd} at 30 and 90 DAS and 4\textsuperscript{th} at 60 DAS with respect to dry matter production of cotton. It was the 2\textsuperscript{nd} best treatment in uptake of N, P and K. The rank of CGR was the 2\textsuperscript{nd} between 90-120 DAS, 3\textsuperscript{rd} between 60-90 DAS and 4\textsuperscript{th} between 30-60 DAS. With respect to LAI, this treatment shared the 1\textsuperscript{st} rank with Pendi + SM at 60 and 120 DAS and held the 2\textsuperscript{nd} rank at 30 DAS while 3\textsuperscript{rd} at 90 DAS. RGR was the 2\textsuperscript{nd} highest between 30-60, 60-90 and 90-120 DAS.

SM ranked 2\textsuperscript{nd} in producing number of bolls plant\textsuperscript{-1}, SI and B:C ratio. It was the 3\textsuperscript{rd} best with respect to number of sympodial branches plant\textsuperscript{-1}, fruiting points plant\textsuperscript{-1}, boll weight, LI, CEY, gross return and net return. It occupied the 4\textsuperscript{th} rank in number of bolls m\textsuperscript{-2}, boll setting percentage, ginning percentage, SCY, LY and WI.
This treatment could be recommended for the areas where paddy straw is abundantly available at a cheaper rate.

6.3.4 Hand weedings at 30 and 50 DAS (HW) was the 2nd best treatment in reducing grasses, 4th in sedges and 3rd in both BLW and total weed density at 30 DAS. At 60 and 90 DAS, it stood 1st with regard to all types of weeds and total weed density. With respect to weed dry weight, this was 3rd at 30 DAS and 1st at 60 and 90 DAS. It recorded the lowest WCE at 30 DAS and the highest at 60 and 90 DAS. The lowest quantity of N, P and K was depleted by weeds in this treatment.

HW held the 1st position in plant height and canopy diameter at 60 and 90 DAS, 2nd at 120 DAS and 4th at 30 DAS. It was 3rd with respect to dry matter of cotton at 60 DAS and 4th at 30, 90 and 120 DAS. It was the 3rd best treatment in uptake of N, P and K by cotton. The CGR was the highest with this treatment between 30-60 DAS and 4th between 60-90 and 90-120 DAS. With respect to LAI, this treatment held the 3rd rank at 30 DAS and 2nd at 60, 90 and 120 DAS. The RGR was the 2nd highest between 30-60 and 90-120 DAS and 3rd between 60-90 DAS.

HW had the 2nd rank with respect to number of sympodial branches plant\(^{-1}\), fruiting points plant\(^{-1}\), bolls plant\(^{-1}\), bolls m\(^{-2}\), boll setting percentage, boll weight, ginning percentage, SCY, LY, CEY, WI, gross return, net return and B: C ratio. It ranked 3rd and 4th in LI and SI, respectively and shared the 1st rank in B:C ratio with Pendi + SM.

This treatment could be recommended for the areas where timely availability of labourers is ensured. Sometimes, heavy and incessant rains hinder hand weeding resulting in yield reduction.

6.3.5 The unweeded control (UC) recorded the maximum number of grasses, sedges, BLW, total weed density and weed dry weight at 30, 60 and 90 DAS. The removal of N, P and K by weeds was the highest at 90 DAS.
UC recorded the smallest plants, the narrowest canopy and the lowest dry matter of cotton at all the dates of observation. The uptake of N, P and K was also the lowest. The lowest CGR, LAI and RGR was recorded in this treatment.

UC ranked 3rd in B:C ratio and 4th with respect to fruiting points plant\(^{-1}\), number of bolls plant\(^{-1}\), boll weight, LI, CEY, gross return and net return. This treatment held the 5th rank in sympodial branches plant\(^{-1}\), bolls m\(^{-2}\), boll setting percentage, ginning percentage, SI, SCY, LY and WI.

6.4 Effects of weed management practices on intercrops

The integrated approach of Pendi + SM ranked 1st with respect to number of nodules plant\(^{-1}\), nodule dry weight plant\(^{-1}\), plant height, LAI, aerial biomass, number of pods plant\(^{-1}\), number of seeds pod\(^{-1}\), 100-seed weight and seed yield. It was the 2nd best treatment in producing root length of all the intercrops like soybean, cowpea and black gram. In order of efficiency, other weed management treatments were HW, Pendi, SM and UC.

6.5 Studies on soil microflora

The population of the soil microflora like fungi, bacteria and actinomycetes increased at 30 DAA from the initial value at the time of sowing in all the intercropping systems. The population at 60 DAA had slightly increased from that in 30 DAA in all the systems. However, it decreased at 90 DAA and increased at 120 DAA in almost all the systems. The results implied that there was no harmful effect of the intercropping systems on the population of soil microflora.

The weed management practices did not have any adverse effect on the initial fungal population at 30 DAA. However, the population was significantly reduced from the unweeded control plot in Pendi alone and Pendi + SM. At 60 DAA, the population had slightly increased from that in 30 DAA in all the treatments. It decreased at 90 DAA and 120 DAA in all the treatments. The weed management practices did not have any detrimental effect on the soil microflora.
6.6 Residual soil fertility after harvest

C + BG intercropping system was the best in recording the highest residual OC, available N, P and K after harvest. C+ S shared the 1st rank with C + BG in OC and available P. It held the 2nd position in recording N and K. C + C occupied the 2nd rank in OC, P and K and 3rd in N. SC held the 2nd rank with respect to OC, P and K and 4th rank in N.

The integrated approach of Pendi + SM ranked top with respect to soil residual OC, N, P and K after harvest. HW shared the 1st rank with Pendi + SM in OC; held 2nd position with respect to N, P and K. SM shared the 1st rank with Pendi + SM in OC and 2nd rank with HW in P and K and held the 3rd rank in N. There was no significant difference in OC level in UC from Pendi + SM. UC recorded 4th highest N and 2nd highest P and K at harvest. Pendi alone was 2nd in OC and P, 5th in N and 3rd in K. There was slight build up of soil OC, available N, P and K from the initial values both in intercropping systems and weed management practices.

CONCLUSION

From the results, it might be concluded that the integrated approach of pre-em application of pendimethalin @ 1.0 kg ha\(^{-1}\) with straw mulching at 30 DAS was the best treatment in management of weeds in the cotton based intercropping systems incurring the highest net monetary return and benefit: cost ratio. Cotton + black gram was the best intercropping system in suppressing the weeds and registering the highest net monetary return and benefit: cost ratio. There were no harmful effects on soil microflora by the treatments. The build-up of soil nutrients after the two years of cultivation was observed.
FUTURE SCOPE OF RESEARCH

Weed management plays a very important role in increasing yield in a high value commercial crop like cotton. Intercropping of legumes in cotton is a beneficial proposition for the farmers as it adds to the net return and help in suppressing weeds due to temporal and spatial use of intervening land area under wide spaced longer duration cotton crop. Very less work have been done on the aspect of integrated weed management in cotton based intercropping systems and hence there is wide scope for future research.

1. More experiments should be taken up in different agro-ecological situations with varied soil types for more refined and accurate recommendations to the farming community.

2. More emphasis should be given for identification of the major weeds infesting the cotton crop and investigating their biology for designing the most accurate integrated approach for their management.

3. Survey should be carried out to identify the most effective farmers’ practices of weed management and to refine those in reducing the drudgery if any and make those more cost effective for better adoption by the farmers.

4. Post-em herbicides may be deployed with pre-em pendimethalin for more efficient and economic results.

5. More investigations to be carried out on the use of different types of locally available low cost mulching materials like dry leaves, grasses, sugarcane trashes and straw of paddy, wheat and ragi.

6. Emphasis should be given to identify the suitable pulse varieties having shorter duration, high yield potential and resistance to pest and diseases as intercrops for the warm-wet (kharif) season.
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