Indian Journal of Agronomy **55** (4): 270–275 (December 2010)

Agronomic and economic evaluation of alternative cropping systems for FCV tobacco (*Nicotiana tabacum*) on Vertisols of Andhra Pradesh

S. KASTURI KRISHNA[1], S.V. KRISHNA REDDY, P. HARISHU KUMAR, V. KRISHNAMURTHY AND M. NAGESWARA RAO

Division of Crop Production, Central Tobacco Research Institute, Rajahmundry, Andhra Pradesh 533 105

Received: April, 2010

ABSTRACT

There is scope in tobacco growing regions for cultivation of maize and soybean during *kharif* on rainfed vertisols. Conserving soil moisture and reducing soil moisture losses during preparatory tillage and sowing of *rabi* crops is a great challenge for successful crop production on rainfed vertisols. Therefore, present field experiment conducted in *kharif* and *rabi* of 2002-03 to 2004-05 at Rajahmundry, to evaluate alternative cropping systems to FCV tobacco (*Nicotiana tabacum* L.). Results revealed that the mean tobacco leaf-equivalent yield (TLEY) of system and net returns were higher by 28.6 and 65.2% in maize (*Zea mays* L.) based sequences as compared to those in soybean [*Glycine max* (L.) Merr.] based sequences (777 kg/ha and Rs 26,389/ha). Maize based crop sequences recorded significantly higher soil pH and available P, while soybean based crop sequences recorded higher organic C, available N and K. Minimum tillage recorded significantly higher TLEY and net returns than zero tillage. Amongst different *rabi* crops, fallow-tobacco and sequential tobacco recorded significantly higher TLEY of system and net returns. Among *rabi* sequential grain crops, highest mean TLEY and net returns were recorded in redgram [*Cajanus cajan* (L.) Millsp.] followed by chickpea (*Cicer arietinum* L.). It was concluded that fallow-tobacco is most profitable however; *kharif* maize with minimum tillage of *rabi* crops viz. redgram, chickpea and horsegram is next best option in Vertisols of Andhra Pradesh.

Key words: Alternative crop sequences, Economics, Net returns, Soil fertility, Tobacco, Yield

India produces about 0.7 m t of tobacco (*Nicotiana tabacum* L.) leaf annually from 0.4 m ha. Of this, Flue-Cured Virginia (FCV) tobacco accounts for 0.322 m t production from 0.26 m ha (Tobacco Board, 2008). Tobacco with the present buoyancy in world market prices fetches very high net returns to its growers. India being a signatory to Framework Convention on Tobacco Control (FCTC) under World Health Organization (WHO) is under obligation to reduce tobacco production to 50% of the present level by 2020. In order to wean away farmers from tobacco cultivation it is essential to provide the farmers with next best cropping options in place of tobacco. Fallow-tobacco monoculture with conserved soil moisture during post rainy season is prevalent in Vertisols of coastal Andhra Pradesh. In the present scenario of tobacco production, particularly in Vertisols, where there is anti tobacco campaign, crop diversification is highly essential. Earlier studies revealed that mono-cropping of other crops is not as remunerative as that of tobacco, while cropping systems are more remunerative (Kasturi Krishna *et al*., 2007 and Krishna Reddy *et al*., 2007). Maize (*Zea mays* L.), and soybean [*Glycine max* (L.) Merr.], have occupied a prominent place in cereal and oilseed production in India. There is scope in tobacco growing regions for maize and soybean cultivation during *kharif* on rainfed Vertisols. Conserving soil moisture and reducing soil moisture losses during preparatory tillage and sowing of the *rabi* crops is a great challenge for successful crop production on rainfed Vertisols. Reduced tillage operations instead of conventional tillage can be one of the options available to conserve soil moisture. Against this backdrop, the present investigation was carried out to devise appropriate tillage method and to find out suitable *rabi* crops succeeding *kharif* maize and soybean for getting higher productivity and profitability in comparison to fallow- FCV tobacco and also to study the changes in soil fertility.

MATERIALS AND METHODS

A field experiment was conducted during rainy (*kharif*) and post rainy (*rabi*) seasons from 2002-03 to 2004-05 at the research farm of Central Tobacco Research Institute, Rajahmundry, (16° 59’ N and 81° 48’ E at 25.3 m above

[1]**Corresponding author** (E mail: krishnakasturi@rediffmail.com)

mean sea-level) in East Godavari district of Andhra Pradesh. It is a hot dry sub humid agro-ecological sub-region (semi-arid tropical climate) with an average annual rainfall of 1,100 mm. The soils are silty clay (sand, silt and clay content in 0-22.5 cm soil layer was 17, 32 and 51% and in 22.5-45.0 cm it was 16, 31 and 53%, respectively). The Godavari Deltaic alluvium-derived Vertisols have slightly alkaline pH (7.75), low electrical conductivity (0.30 dS/m), available N (230 kg/ha) and organic C (0.44%) and high available phosphorus (32.0 kg/ha) and potassium (437 kg/ha). Soil moisture at 33 k Pa in 0-22.5 and 22.5-45.0 cm soil layer was 43 and 42.5% (w/w basis), whereas at 1500 k Pa it was 25 and 25.4% (w/w basis), respectively. The bulk density of the respective soil layers was 1.27 and 1.29 Mg/m^3.

The experiment was carried out on fixed lay-out in split-plot design and replicated three times. The experiment consisted of combination of two *kharif* crops viz. maize and soybean and two tillage practices viz. zero tillage (weeds were removed manually and only furrows were opened for sowing) and minimum tillage (weeds were removed by one harrowing and seed furrows were opened for sowing) in main-plots, and eight *rabi* crops viz. horsegram [*Macrotyloma uniflorum* (Lam.) Verdc.], redgram [*Cajanus cajan* (L.) Millsp.], chickpea (*Cicer arietinum* L.), blackgram [*Vigna mungo* (L.) Hepper], mustard [*Brassica juncea* (L.) Czernj & Cosson], coriander (*Coriandrum sativum* L.), tobacco succeeding *kharif* crops and fallow-FCV tobacco (control i.e. present farmer's practice) in sub-plots. Seeds of maize hybrid and soybean were direct sown during the second week of July and the crops were harvested in the second fortnight of October in all the three seasons. After harvesting *kharif* maize and soybean, the tillage treatments were imposed in maize and soybean stubbles and *rabi* crops were direct sown in the first week of November. In fallow plots weeds were removed manually. Sixty-day old seedlings of FCV tobacco were planted during first fortnight of November.

Table 1. Cultural practices followed for *kharif* and *rabi* crops

Crop	Cultural practices		
	Variety	Spacing (cm)	Fertilizer (kg/ha) $N\text{-}P_2O_5\text{-}K_2O$
Soybean	'JS 335'	45 x 10	30-60-40
Maize	'GSF 2 hybrid'	60 x 20	60-50-50
Horsegram	'PDM-1'	30 x 10	20-40-00
Redgram	'ICPL 85063'	45 x 10	20-45-00
Chickpea	'Kranthi'	30 x 10	20-50-00
Blackgram	'LBG-27'	30 x 10	20-50-00
Mustard	'Kranthi'	30 x 15	60-30-30
Coriander	'Swathi'	30 x 10	30-40-20
Tobacco	VT-1158	70 x 50	50-00-00

The recommended packages of practices were followed to grow the *kharif* crops in rainy season and grain crops and FCV tobacco in *rabi* with conserved soil moisture.

The rainfall received during *kharif* was 566 mm (44 rainy days) in 2002, 453 mm (37 rainy days) in 2003 and 905 mm (53 rainy days) in 2004. The amount of rainfall during *rabi* season was 26 mm (8 rainy days) in 2002-03 and 101 mm (12 rainy days) in 2004-05 seasons. No rainfall was recorded during *rabi* 2003-04 season. During 2003-04 season, 25 mm of irrigation water was applied from harvested rain water after harvesting maize and soybean to facilitate proper germination and stubble decomposition as residual soil moisture was less. Mean maximum and minimum temperatures during *rabi* season were, respectively, 31.2 and 17.7°C in the first season, 31.1 and 16.8°C in the second season and 30.6 and 17.7°C in the third season.

Tobacco leaves were harvested at maturity by priming 2-3 matured leaves each time at 7-8 days interval and cured in the flue-curing barn, and on an average eight primings were done to complete the harvesting of tobacco. The data on cured leaf of tobacco and yield of *kharif* and *rabi* crops were recorded. Economic analysis was done based on the prevailing market prices of the inputs and produce i.e. tobacco cured leaf @ Rs 86,400/t, maize @ Rs 7,000/t, soybean @ Rs 12,000/t, horsegram @ Rs 18,000/t, redgram @ Rs 38,500/t, chickpea @ Rs 24,000/t, blackgram @ Rs 46,000/t, mustard @ Rs 29,000/t and coriander @ Rs 31,000/t. The tobacco leaf-equivalent yield (TLEY) was computed by converting maize and soybean yield and *rabi* crops yield based on the market prices. Sustainable yield index (SYI) was derived based on estimated average yield, estimated standard deviation and observed maximum yield. Soil samples were collected from 0-22.5 cm depth at pre-sowing and post-harvest after three crop cycles and used to determine pH, organic C, available N, P and K contents following standard procedures.

RESULTS AND DISCUSSION

Kharif crops productivity

Grain yield of maize ranged from 5.20 to 5.85 t/ha with a mean grain and stover yield of 5.52 and 11.71 t/ha (Table 2). Grain yield of soybean ranged between 1.84 and 2.10 t/ha with a mean grain and straw yield of soybean 1.99 and 4.21 t/ha. Tillage treatments given prior to seeding of post rainy season (*rabi*) crops did not exhibit any carry over effect on the productivity of succeeding rainy season (*kharif*) maize and soybean as the plots with minimum tillage (MT) prior to seeding of *rabi* crops resulted in only a marginal increase (up to 2%) in the yield of maize and soybean over zero tillage (ZT) plots. Thakur *et al*. (2000)

also reported similar results due to different degrees of tillage operations in soybean based cropping systems in Vertisols of Central India.

Rabi crops productivity

Among the *rabi* grain crops, chickpea, redgram and horsegram produced normal yields followed by mustard and coriander in all the three years (Table 3). The yield of *rabi* sequence crops was comparatively higher succeeding *kharif* maize than that of after soybean. The yields of *rabi* crops were slightly better under MT than with ZT. The grain yields of *rabi* crops viz. horsegram, redgram, mustard and coriander and cured leaf yield of maize-tobacco and soybean-tobacco were higher during 2004-05 season compared with those of 2002-03 and 2003-04 seasons. The residual soil fertility (because of leaving maize and soybean stubbles in the field) and the effective rainfall received during post rainy season in 2004-05 helped the *rabi* crops to perform better and produce more yields. Redgram was the most benefited as its duration was 15 days more than other *rabi* grain crops. The cured leaf yield of tobacco in maize-tobacco and soybean-tobacco, increased proportionately when compared to fallow-tobacco in the third year (2004-05) with the receipt of more (101 mm) rainfall in *rabi* season than that of first season (26 mm) indicating the lack of sufficient soil moisture in maize/soybean-tobacco and availability of sufficient soil moisture in fallow-tobacco. This shows that tobacco succeeding maize and soybean responds well to post rainy season rainfall as available residual moisture after *kharif* maize and soybean was less and insufficient to tobacco when compared to soil moisture in fallow-tobacco. The productivity of FCV tobacco was comparatively more with MT than with ZT. Smith and Peedin (2002) reported that quality of no till flue cured tobacco has been equal to that of conventional tilled tobacco, while yields have tended to be lower.

System productivity

Results showed that *kharif* maize recorded significantly higher system productivity in terms of TLEY which was 29.88, 27.20 and 28.66% more than *kharif* soybean in first, second and third years, respectively (Tables 4 and 5). Though the reasons for lower yield in soybean based *rabi* sequence crops were not known clearly, the allelopathic effect of soybean could have been one of the possible causes for yield suppression. Huber and Abney (2008) also reported allelopathic effect of soybean on succeeding wheat. SYI was higher by 28.2% with *kharif* maize than *kharif* soybean. MT recorded significantly higher TLEY by 30.1 kg/ha (3.33%) and 38.8 kg/ha (3.97%) than ZT during second and third years, respectively. Thakur *et al*. (2000) and Shiv Dhar *et al*. (2008) reported increased productivity in post-rainy season crops due to conventional tillage than ZT. Slightly higher SYI (2.27%) was recorded in MT than ZT. Fallow-tobacco recorded significantly higher TLEY and SYI followed by sequential tobacco, redgram and chickpea when compared with other *rabi* sequences. Lower TLEY was recorded with *rabi* blackgram sequence due to less grain yield and more vegetative growth of blackgram. Amongst different *rabi* crop sequences, SYI was higher with fallow-tobacco followed by maize/soybean-tobacco and redgram and chickpea.

Economics

Economics of treatments revealed that net returns and net B: C ratios were significantly higher in maize based sequences than soybean based sequences in all the three years (Table 6). MT resulted in significantly higher net returns and B: C ratio than ZT in 2004-05 only. Among the *rabi* crops, fallow-tobacco resulted in higher net returns and B: C ratio in all the seasons. Among the grain crops higher net returns and net B: C ratio were recorded by redgram in first and third years and chickpea in second year.

Soil fertility status

As compared to initial soil fertility, mean residual soil fertility determined after three crop cycles showed lower soil pH, slight improvement in organic C and decrease in available soil N P K (Table 6). However, soybean based systems showed higher soil organic C (0.06%) and available soil N (1.26%) compared to initial soil fertility. Among the *kharif* crops, status of soil available P was

Table 2. Yield attributes and yields of *kharif* maize and soybean

Year	Maize				Soybean			
	Cobs/ha (no.)	Grains/ cob	1,000-grain weight (g)	Grain yield (t/ha)	Pods/ plant	Seeds/ pod	100-seed weight (g)	Yield (t/ha)
2002-03	50,900	371.0	274.5	5.20	29.0	2.48	11.5	1.84
2003-04	53,550	373.0	276.2	5.50	32.0	2.53	11.7	2.10
2004-05	55,180	385.0	276.6	5.85	31.0	2.53	11.7	2.04
Mean	53,210	376.3	275.8	5.52	30.7	2.51	11.6	1.99

Table 3. Yield of *rabi* crops (kg/ha) as influenced by *kharif* crops (maize and soybean) and tillage method.

Treatment	2002-03						2003-04						2004-05					
	Maize			Soybean			Maize			Soybean			Maize			Soybean		
	ZT	MT	Mean	ZT	MT	Mean	ZT	MT	Mean	ZT	MT	Mean	ZT	MT	Mean	ZT	MT	Mean
Rabi crop																		
Horsegram	1,190	1,190	1,190	1,054	1,088	1,071	1,022	1,046	1,034	951	973	962	1,401	1,474	1,437	1,360	1,395	1,377
Redgram	748	782	765	680	714	697	702	736	719	612	691	656	1,463	1,519	1,491	1,349	1,395	1,372
Chickpea	952	1,019	986	816	952	884	1,461	1,531	1,496	1,428	1,428	1,428	1,315	1,397	1,356	1,191	1,214	1,202
Blackgram	306	306	306	272	272	272	237	282	259	211	211	211	211	211	211	202	211	206
Mustard	816	850	833	714	748	731	714	714	714	511	544	523	959	928	944	907	1,009	958
Coriander	680	714	697	612	612	612	544	612	578	544	646	595	895	872	883	703	667	685
Tobacco	1,215	1,246	1,230	860	887	873	1,455	1,500	1,477	960	1,017	983	1,435	1,581	1,508	1,017	1,193	1,105
Fallow-Tobacco*	1,636	1,653	1,644	1,636	1,653	1,644	1,806	1,908	1,857	1,816	1,884	1,850	1,661	1,753	1,707	1,650	1,753	1,701

*The corresponding plots in maize and soybean systems were kept fallow during *kharif*. ZT- Zero tillage; MT - Minimum tillage

Table 4. System productivity {TLEY (kg/ha)} as influenced by *kharif* crop (maize and soybean) and tillage method (zero tillage and minimum tillage) and *rabi* crop (2002-03 to 2004-05) and SYI

Treatment	Tobacco leaf-equivalent yield			SYI
	2002-03	2003-04	2004-05	
Kharif crop				
Maize	922.4	996.5	1,077.4	0.50
Soybean	710.2	783.4	837.4	0.39
SEm±	9.2	6.3	7.5	
CD (P=0.05)	31.9	21.8	26.1	
Method of tillage				
Zero tillage	808.5	875.1	938.0	0.44
Minimum tillage	824.1	905.2	976.8	0.45
SEm±	9.2	6.3	7.5	
CD (P=0.05)	NS	21.8	26.1	
Rabi crop				
Horsegram	574.0	576.5	6.71.9	0.31
Redgram	664.2	674.0	1,016.5	0.34
Chickpea	598.1	774.7	734.0	0.35
Blackgram	492.3	493.8	489.8	0.27
Mustard	600.9	577.0	697.8	0.32
Coriander	573.2	579.1	660.0	0.32
Tobacco	1,383.3	1,601.7	1,685.1	0.77
Fallow-Tobacco*	1,644.5	1,844.3	1,704.2	0.88
SEm±	14.1	16.5	19.5	
CD (P=0.05)	39.1	45.5	54.2	

higher with maize and organic C and available N and K were higher with soybean as compared to each other. ZT showed significantly higher soil available P and K than that of MT. Among *rabi* crops, soil pH values were higher with tobacco and lower with blackgram. In general soil pH values were lower with crop sequences involving *rabi* grain legumes (pulses) than other sequences. Change in soil pH may be attributed to the legume, which takes up high concentrations of base cations, and in the process of balancing internal charge, release H^+ into the rhizosphere there by causing soil acidification (Crews and Peoples, 2004). Soil organic C and available N were higher with sequential blackgram followed by other sequences involving *rabi* grain legumes (pulses). This might be due to production of luxuriant vegetative growth and lower grain yields in blackgram thus leaving higher amount of N fixed by it in the soil that increased the organic C and available soil N (Kasturi–Krishna *et al*., 2007). The lowest available soil N was noticed in sequential mustard due to exhaustive nature of *kharif* maize/soybean and mustard. Available P was significantly higher (27.3 kg/ha) with tobacco and lower with sequential redgram. This could be due to higher quantity of P removal by soybean and redgram (being legumes) sequence and lower quantity of P requirement (5-6 kg/ha) by tobacco. The higher amounts of P re-

Table 5. System productivity {TLEY (kg/ha)} as influenced by interaction effect of tillage practices (ZT- Zero tillage; MT - Minimum tillage) and *rabi* crop

Tillage method	2002-03		2003-04		2004-05	
	MT	ZT	MT	ZT	MT	ZT
Rabi crop						
Horsegram	572.2	575.7	574.1	579.0	666.2	677.5
Redgram	656.6	671.7	661.4	686.6	1005.1	1027.9
Chickpea	584.0	612.2	769.9	779.6	726.7	741.3
Blackgram	492.3	492.3	487.9	499.8	488.6	491.0
Mustard	595.2	606.6	574.2	579.7	691.8	703.8
Coriander	570.2	576.3	563.8	594.3	665.3	654.7
Tobacco	1361.8	1404.9	1576.5	1627.0	1604.6	1765.6
Fallow-Tobacco*	1636.0	1653.0	1792.7	1896.0	1655.5	1753.0
SEm±		19.9		23.1		27.6
CD (P=0.05)		NS		NS		NS

Table 6. Economics and soil fertility as influenced by *kharif* crop, tillage method and *rabi* crop

Treatment	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)			Net benefit : cost ratio			pH	Organic C (%)	Available nutrients (kg/ha)		
		2002-03	2003-04	2004-05	2002-03	2003-04	2004-05			N	P	K
Kharif crop												
Maize	42,691	37,005	43,408	50,398	0.87	1.02	1.18	7.65	0.40	221.2	27.6	424.7
Soybean	40,756	20,607	26,963	31,598	0.51	0.66	0.78	7.20	0.50	232.9	24.4	429.7
SEm±		318	544.5	654				0.04	0.01	0.6	0.1	1.1
CD (P=0.05)		1,101	1,884	1,962				0.13	0.03	2.2	0.3	4.0
Method of tillage												
Zero tillage	41,243	28,614	34,363	39,802	0.69	0.83	0.96	7.46	0.46	228.0	26.5	430.2
Minimum tillage	42,205	28,997	36,009	42,195	0.69	0.85	1.00	7.40	0.44	226.1	25.5	424.2
SEm±		318	544.5	654				0.04	0.01	0.6	0.1	1.1
CD (P=0.05)		NS	NS	1,962				NS	NS	NS	0.3	4.0
Rabi crop												
Horsegram	29,010	20,579	20,804	29,040	0.71	0.72	1.00	7.43	0.46	228.2	25.7	434.5
Redgram	31,459	25,927	26,775	56,368	0.82	0.85	1.79	7.35	0.47	237.3	25.1	418.5
Chickpea	32,665	19,011	34,273	30,754	0.58	1.05	0.94	7.38	0.47	232.0	25.9	432.5
Blackgram	27,490	15,044	15,178	14,828	0.55	0.55	0.54	7.29	0.48	239.0	26.5	430.5
Mustard	32,110	19,808	17,742	28,182	0.62	0.55	0.88	7.50	0.43	214.5	25.5	426.5
Coriander	30,536	18,994	19,496	26,492	0.62	0.64	0.87	7.46	0.44	219.6	25.8	433.5
Tobacco	76,460	43,059	61,928	69,136	0.56	0.81	0.90	7.59	0.44	218.6	27.3	414.5
Fallow-Tobacco*	74,060	68,025	85,290	73,187	0.92	1.15	0.99	7.80	0.42	223.1	30.9	429.5
SEm±		1,713	1,416	1,695				0.05	0.01	2.2	0.3	1.6
CD (P=0.05)		4,729	3,921	4,678				0.13	0.02	6.2	0.9	4.4
Initial								7.75	0.44	230.0	32.0	437.0

*The corresponding plots in maize and soybean systems were kept fallow during *kharif*

quirement by soybean resulted in depletion of available soil P in soybean-based sequences (Przednowek *et al*., 2004). Available K status of the soil was higher with horsegram and lower with tobacco. The higher amounts of K requirement by tobacco coupled with P and K omission in black soil tobacco resulted in depletion of available soil K (Flower, 1999) in sequential tobacco.

It was concluded that fallow-tobacco is most profitable however; *kharif* maize with minimum tillage of *rabi* crops viz. redgram, chickpea and horsegram is next best option in Vertisols of Andhra Pradesh.

REFERENCES

Crews, T.W. and Peoples, M.B. 2004. Legume versus fertilizer sources of nitrogen: ecological tradeoffs and human needs. *Agricultural Ecosystems and Environment* **102**: 279–297.

Flower, K.C. 1999. Agronomy and Physiology: Field practices. In: *Tobacco - Production, Chemistry and Technology.* (Davis D.L. and Nielsen M.T. Eds.), 83 p. Cambridge, Great Britain : Blackwell Science Ltd. University Press.

Huber, D.M. and Abney, T.S. 2008. Soybean allelopathy and subse-

quent cropping. *Journal of Agronomy and Crop Science* **157**(2): 73–78.

Kasturi–Krishna, S., Krishna Reddy, S.V., Singh, K.D., Subba Rao, R., Harishu Kumar, P. and Krishnamurty, V. 2007. Yield, quality and economics of FCV tobacco (*Nicotiana tabacum*) in relation to preceding crops and nitrogen in Vertisols of Andhra Pradesh. *Indian Journal of Agronomy* **52**(3): 212–215.

Krishna Reddy, S.V., Kasturi Krishna, S., Prasad Rao, J.A.V., Harishu Kumar, P. and Krishnamurty, V. 2007. Effect of application of biofertilisers to soybean (*Glycine max*) and nitrogen to tobacco (*Nicotiana tabacum*) in soybean – tobacco cropping system. *Indian Journal of Agronomy* **52**(4): 294–299.

Przednowek, D.W.A., Entz, M.H., Irvine, B., Flaten, D.N. and Thiessen Martens, J.R. 2004. Rotational yield and apparent N benefits of grain legumes in southern Manitoba. *Canadian Journal of Plant Science* **84**:1093–1096.

Shiv Dhar, S., Das, S.K., Sunil Kumar, and Singh, J.B. 2008. Effect of tillage and soil moisture conservation practices on crop yields of chickpea (*Cicer arietinum*) and soil properties under rainfed conditions. *The Indian Journal of Agricultural Sciences* **78**(12): 1042–1047.

Smith, W.D. and Peedin, G.F. 2002. No-till flue-cured tobacco production. North Carolina *Flue-Cured Tobacco Production Guide*, NC State University North Carolina, USA Centre for IPM: Chapter 13.

Thakur, H.S., Sharma, R.A., Nadkarni, P.G. and Raghuwanshi, R.K.S. 2000. Studies on the influence of different degrees of tillage operations on soybean based cropping systems grown on Vertisols of Central India. *Crop Research* **19**(1): 17–22.

Tobacco Board, 2008. *Annual Report, 2007-08*. 143 & 154 pp. Tobacco Board, Government of India, Ministry of Commerce & Industry, Guntur, Andhra Pradesh.