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ACKNOWLEDGEMENTS. This research was supported by a grant from the Department of Science and Technology (DSTDPRP scheme), Government of India. We thank Dr Madhavan Nair and Dr Raghu Pullakhandam (National Institute of Nutrition, Hyderabad) for the training provided, and Venu and Subrahmanya for discussions on *Rasayana* and Madhuri and Anjaneyulu (I-AIM) for technical assistance. We thank Prof. Upendra (IISc), Prof. Nagarajan, Ashwini and Menon (I-AIM) for their constructive comments, and the Director, FRLHT-IAIM, Bangalore for providing the research facilities.

Received 16 June 2014; revised accepted 31 August 2014

Evaluation of weather-based crop insurance products for *kharif* groundnut

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Weather-based crop insurance scheme (WBCIS) products proposed by four insurance providers was compared and evaluated using historical weather data for piloting WBCIS on *kharif* groundnut in Coimbatore, Dharmapuri, Theni, Tirunelveli and Virudhunagar districts of Tamil Nadu. Water deficits during the vegetative phases of groundnut crop generally delay flowering and maturity thereby reducing the crop growth and yield. The study revealed that the deficit rainfall risk was more pronounced in all the above-mentioned districts, whereas the risk of excess rainfall impact could be clearly observed in Theni district. Though the occurrence of strike events was for phase-I of deficit rainfall cover, the rate per mm of rainfall fixed by IFFCO–TOKYO was quite low. The product designed for HDFC–ERGO and MS–Cholamandalam was similar, whereas the product for AIC and IFFCO–TOKYO was designed with little variation in context to excess rainfall cover and consecutive dry days. The compensation benefit realized by the farmers of Virudhunagar and Dharmapuri districts was higher followed by Theni because the compensation rate per mm of rainfall fixed by the company was higher, which favours the farmers.

Keywords: Insurance companies, payout, product design, strike events.

AGRICULTURE provides livelihood for 60% of rural population in India and contributes to 35% of the country's gross national product (GNP). The greatest risk to crop yields in Indian agriculture is attributed to the variability of seasonal rainfall as well as the uncertainty in the amount and its distribution in a given season[1]. On an average, 12 m ha of crop area is affected annually by calamities, severely impacting the yields and total agricultural production in India[2]. Groundnut is a legume that belongs to the pea and bean family. More than half of the production area, which accounts for 70% of the groundnut growing area falls under arid and semi-arid regions, where peanuts are frequently subjected to drought stress for different durations and intensities[3].

The Government of India (GoI) had introduced the Comprehensive Crop Insurance Scheme (CCIS) in 1985. Subsequently this was replaced by the National Agricultural

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Table 1. Study districts, companies notified for 2011–12, reference weather station and sum insured by different insurance companies

District	Insurance company	Weather station	Data period	Sum insured (Rs)	Farmer's premium (Rs)
Dharmapuri	Agricultural Insurance Corporation (AIC)	Regional Research Station, Paiyur	1981–2005	10,000	350
Virudhunagar	AIC	Regional Research Station, Arupukkottai	1985–2010	10,000	350
Coimbatore	IFFCO–TOKYO	Tamil Nadu Agricultural University, Coimbatore	1981–2010	10,000	350
Theni	HDFC–ERGO	Horticulture College and Research Institute, Periyakulam	1981–2010	9,000	317
Tirunelveli	MS–Cholamandalam	Rice Research Station, Ambasamudram	1981–2010	10,000	350

Table 2. Deficit rainfall cover proposed by AIC for Dharmapuri and Virudhunagar districts

	P-I (1 July–10 August)			*P*-II (11 August–10 September)		
	S_1	S_2	E	S_1	S_2	E
Dharmapuri						
DRC (Rs 5000/ac)	<45 and > 15 mm	<15 mm	0 mm	<100 and >40 mm	<40 mm	0 mm
Compensation	Rs 12/mm	Rs 113/mm	Rs 2000	Rs 12/mm	Rs 57/mm	Rs 3000
Virudhunagar						
DRC (Rs 5000/ac)	<45 and >15 mm	<20 mm	0 mm	<70 and >30 mm	<30 mm	0 mm
Compensation	Rs 15/mm	Rs 108/mm	Rs 3000	Rs 10/mm	Rs 87/mm	Rs 3000

P, Phase; S_1, Strike 1; S_2, Strike 2; E, Exit.

Insurance Scheme (NAIS) in 1999–2000, which was based on crop-cutting experiments to assess crop-yield. Despite the large public subsidy a significant majority of India's farmers have remained uninsured largely due to issues in design, particularly the long delays in claims settlement[4]. Hence, GoI and State governments have started providing weather-based crop insurance programmes from 2007 to 2008.

Weather-based crop insurance scheme (WBCIS) is a type of agricultural insurance, which is a means of protecting farmers against financial losses due to uncertainty in seasonal rainfall/unfavourable weather situations[5]. The strike or upper threshold of rainfall corresponds to the 30-year average accumulated rainfall of the district reference weather station, while the exit or lower threshold is intended to equal the water requirement of the respective crop necessary to avoid complete crop failure[6].

Different insurance providers have developed their own WBCIS products for implementation in different districts. In the present study, an attempt has been made to compare and evaluate the WBCIS products designed by four insurance companies with respect to *kharif* groundnut crop in order to arrive at a balanced product which would benefit the farmers and at the same time ensure viability of the insurance products.

The Government of Tamil Nadu has notified a particular insurance company for a district in which another insurance company cannot function. Table 1 gives the study districts, companies notified by the Government of Tamil Nadu for the year 2011–12, weather station from where the historical weather data were obtained, data period, sum insured and farmer's premium.

The different weather perils covered under the insurance package are as follows:

The deficit rainfall-based insurance is intended to provide protection to the cultivator against declined rainfall, which is deemed to adversely affect the crop during its cultivation period. Deficit rainfall insurance payouts are linked to accumulated low rainfall. Table 2 shows deficit rainfall cover (DRC) product given by Agricultural Insurance Corporation (AIC) for Dharmapuri and Virudhunagar districts.

AIC has suggested S_1, S_2 and E for giving compensation. The remaining companies, viz. IFFCO–TOKYO, HDFC–ERGO and MS–Cholamandalam have proposed only S_1 and S_2. Table 3 shows the product given by IFFCO–TOKYO for Coimbatore. HDFC–ERGO and MS–Cholamandalam have considered only two phases (*P*-II and *P*-III) for paying compensation towards deficit rainfall, which is notified as water deficit index (WDI; Table 4).

Heavy and continuous rainfall within a short period has the potential to cause severe physiological damage to crops, particularly during the maturity and the harvest stages. The indices that have been designed to capture wet spells, aggregate rainfall over a period between two and four consecutive days during the crop growth period are considered for insurance coverage. Table 5 shows the excess rainfall cover (ERC) product given by AIC for Dharmapuri and Virudhunagar districts.

Table 3. Deficit rainfall cover proposed by IFFCO-Tokyo for Coimbatore district

DRC	*P*-I (1 August–15 September)		*P*-II (16 September–17 October)		*P*-III (18 October–30 November)	
Maximum pay out Rs 2500/ac	S_1 <40 and >10 mm	S_2 <10 mm	S_1 <60 and >30 mm	S_2 <30 mm	S_1 <80 and >40 mm	S_2 <40 mm
Compensation	Rs 8/mm	Rs 19/mm	Rs 8/mm	Rs 17/mm	Rs 8/mm	Rs 25/mm

Table 4. Water deficit index (WDI) proposed by HDFC–ERGO for Theni district and MS–Cholamandalam for Tirunelveli district

Theni (maximum payout – Rs 5000/ac)	*P*-II (11 September–31 October)		*P*-III (1 November–30 November)	
WDI	S_1 <105 and >20 mm	S_2 <20 mm	S_1 <70 and >20 mm	S_2 <20 mm
Compensation	Rs 10/mm	Rs 86/mm	Rs 10/mm	Rs 25/mm
Tirunelveli (maximum payout – Rs 4000/ac)	*P*-II (31 August–31 October)		*P*-III (1 November–30 November)	
WDI	S_1 <110 and >25 mm	S_2 <25 mm	S_1 <70 and >20 mm	S_2 < 20 mm
Compensation	Rs 10/mm	Rs 86/mm	Rs 10/mm	Rs 25/mm

Table 5. Excess rainfall cover (ERC) proposed by AIC for Dharmapuri and Virudhunagar districts

	ERC			
	Rainfall in four consecutive days			
	P-I (1 July–15 August)		*P*-II (16 August–15 September)	
Maximum payout: Rs 3500/ac	Strike	Exit	Strike	Exit
Dharmapuri	>140 mm	>240 mm	>130 mm	> 230 mm
Virudhunagar	>100 mm	>200 mm	>80 mm	>180 mm
Compensation	Rs 15/mm	Rs1500	Rs 20/mm	Rs 2000

HDFC–ERGO (Theni) and MS–Cholamandalam (Tirunelveli) proposed ERC in the name of excess rainfall index (ERI). Table 6 shows the product of the mentioned companies and the product given by IFFCO–TOKYO (Coimbatore).

Consecutive dry days (CDD)/dry days index (DDI) is used to construct an index equal to the maximum consecutive dry days within a specified period, where a dry day is defined as one with total rainfall below a threshold value. This cover offers protection for long dry spells during crop growth period[7]. CDD = maximum number of consecutive days with $r_{\text{actual}} < r_{\text{threshold}}$.

Table 7 shows the product offered by different insurance companies. DRC was considered by AIC in two phases of crop growth in two districts, viz. Dharmapuri and Virudhunagar. IFFCO–Tokyo had considered DRC in three phases of crop growth for Coimbatore district. HDFC–ERGO and MS–Cholamandalam have considered WDI only in two phases, viz. phase II and phase III for Theni and Tirunelveli districts. The strikes that occurred during the crop growth period for the ORC/WDI are shown in Figure 1.

For Dharmapuri, in phase I (1 July–10 August), S_1 (rainfall >15 mm and < 45 mm) and S_2 (rainfall <15 mm) occurred four and two times respectively. In phase II (11 August–10 September), S_1 (rainfall > 40 mm and <100 mm) occurred eight times and S_2 (rainfall < 40 mm) occurred three times in 25 years of the evaluation period.

For Virudhunagar, in phase I (1 July–10 August), S_1 (rainfall >15 mm and < 45 mm) and S_2 (rainfall <15 mm) occurred eight and three times respectively. In phase II (11 August–10 September), S_1 (rainfall >30 mm and < 70 mm) occurred six times and S_2 (rainfall < 30 mm) occurred eight times in 26 years of the evaluation period. Water deficits during the vegetative phases generally delay flowering of the crop. Moisture stress during flowering causes flower drop, impairs pollination and during pod setting, it decreases pod weight.

For Coimbatore, in phase I (1 August–15 September), S_1 (rainfall >10 mm and <40 mm) and S_2 (rainfall <10 mm) occurred nine and one time respectively. In phase II (16 September–17 October), the S_1 (rainfall >30 mm and <60 mm) and S_2 (rainfall <30 mm) occurred four and one time respectively. In phase III (18 October–30

Table 6. ERC/excess rainfall index (ERI) for Coimbatore, Theni and Tirunelveli districts

Coimbatore (Rs 5500/ac)	*P*-I (1 August–15 September)	*P*-II (16 September–17 October)	*P*-III (18 November–30 November)
ERC	>100 mm	>100 mm	>150 mm
Compensation	Rs 5/mm	Rs 5/mm	Rs 5/mm
Theni (Rs 4000/ac)	*P*-I (10 August–10 September)	*P*-II (11 September–31 October)	*P*-III (1 November–30 November)
ERI	>35 mm	>120 mm	>75 mm
Compensation	Rs 15/mm	Rs 10/mm	Rs 10/mm
Tirunelveli (Rs 3000/ac)	*P*-I (1 August–30 August)	*P*-II (31 August–31st October)	*P*-III (1 November–30 November)
ERI	>80 mm	>125 mm	>125 mm
Compensation	Rs 10/mm	Rs 10/mm	Rs 10/mm

Rainfall in 2 consecutive days.

Table 7. Consecutive dry days (CDD)/dry days index (DDI) given to study districts

AIC	Dharmapuri and Virudhunagar, starting 10 July to 10 September, maximum payout: Rs 1500/ac If rainfall (>2.5 mm) does not occur in the first 30 consecutive days, Rs 400 is paid (S_1) If rainfall (>2.5 mm) does not occur in the first 35 consecutive days, Rs 650 is paid (S_2) If rainfall (>2.5 mm) does not occur in the first 40 consecutive days, Rs 900 is paid (S_3) If rainfall (>2.5 mm) does not occur in the first 45 consecutive days, Rs 1200 is paid (S_4) If rainfall (>2.5 mm) does not occur in the first 50 consecutive days, Rs 1500 is paid (S_5)
IFFCO–TOKYO	Coimbatore, starting 3 September to 31 October, maximum payout: Rs 2000/ac If rainfall (>2.5 mm) does not occur in the first 28 consecutive days, Rs 160 is paid (S_1) If rainfall (>2.5 mm) does not occur in the first 35 consecutive days, Rs 700 is paid (S_2) If rainfall (>2.5 mm) does not occur in the first 40 consecutive days, Rs 1000 is paid (S_3) If rainfall (>2.5 mm) does not occur in the first 46 consecutive days, Rs 1400 is paid (S_4) If rainfall (>2.5 mm) does not occur in the first 48 consecutive days, Rs 2000 is paid (S_5)
HDFC–ERGO	Theni, starting 11 September to 31 October, maximum payout: Rs 4000/ac If rainfall (>2.5 mm) does not occur in the first 29 consecutive days, no money is paid (S_1) If rainfall (>2.5 mm) does not occur from 30 to 39 consecutive days, Rs 1500 is paid (S_2) If rainfall (>2.5 mm) does not occur for 40 to 49 consecutive days, Rs 2500 is paid (S_3) If rainfall (>2.5 mm) does not occur for more than 50 consecutive days, Rs 4000 is paid (S_4)
MS–Cholamandalam	Tirunelveli, starting 31 August to 31 October, maximum payout: Rs 3000/ac If rainfall (>2.5 mm) does not occur in the first 29 consecutive days, no money is paid (S_1) If rainfall (>2.5 mm) does not occur from 30 to 44 consecutive days, Rs 500 is paid (S_2) If rainfall (>2.5 mm) does not occur for 45 to 54 consecutive days, Rs 1500 is paid (S_3) If rainfall (>2.5 mm) does not occur for more than 55 consecutive days, Rs 3000 is paid (S_4)

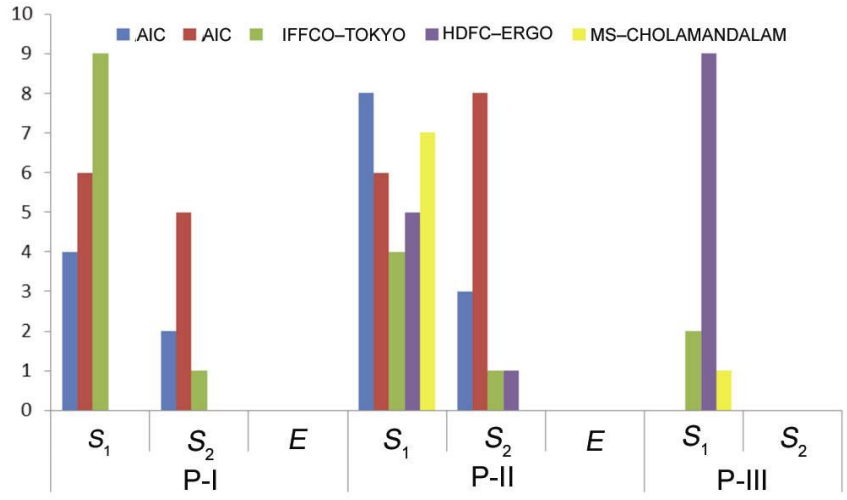

Figure 1. Comparison of strike events for deficit rainfall cover/water deficit index.

November), only S_1 (rainfall >40 mm and <80 mm) occurred two times in the 30 years of study period. Though the occurrence of strike event was higher on the whole, the rate per mm of rainfall fixed by the insurance company was meagre. This indicates an imbalance between the strike rate and compensation, which would give less benefit to farmers.

In Theni and Tirunelveli districts, for phase-III, S_1 and S_2 conditions were similar. In Theni, for phase II (11 September–31 October), S_1 (rainfall >25 mm and <105 mm) and S_2 (rainfall < 25 mm) occurred five and one time respectively. In Tirunelveli, for phase II (31 August–31 October), only S_1 (rainfall > 25 mm and <115 mm) occurred seven times in the 30 years study period.

For phase III, S_1 (rainfall > 20 mm and <70 mm) occurred nine times in Theni district and only once in Tirunelveli district.

Let us now consider ERC/ERI (in any 4 consecutive days). In Dharmapuri for phase I, the strike of >140 mm rainfall occurred once and in phase II, the strike of >130 mm rainfall occurred eight times in 25 years. In Virudhunagar, for phase I the strike of >100 mm rainfall occurred three times and in phase II, the strike of >80 mm rainfall occurred four times in 26 years of evaluation.

In Coimbatore, for phase I, the strike condition of >100 mm rainfall in two consecutive days did not occur even once. In phases II and III, the strike condition of >100 mm rainfall in two consecutive days occurred two and one time respectively, in the 30 years study period. Phase I falls in the middle of the southwest monsoon season where the total amount of monsoonal rainfall received over 30 years was 184 mm. The strike condition needs to be modified based on the past historical analysis of weather data of particular region under study (in any two consecutive days).

In Theni for phase I (10 August–10 September), the strike of >35 mm rainfall occurred 11 times; for phase II, the strike of >120 mm rainfall occurred six times and for phase III, the strike of >75 mm rainfall occurred nine times in 30 years of evaluation. Evaluation of the analysis indicated that this district is prone to high risk of excess rainfall impact on crop growth. More quantum of rainfall during early plant growth stages (first 50 days after planting) may result in excessive vegetative growth and shallow root development that leads to poor peg and pod development. Excessive rainfall during the maturity phase of the crop can increase risk of leaf and pod diseases and peg deterioration resulting in harvesting problems in groundnut[8].

In Tirunelveli, for phase I (1 August–30 August), the strike of >80 mm rainfall and for phase II, the strike of >125 mm did not occur even once. The reason attributed in the case of Coimbatore holds true for this district as well, wherein the southwest monsoon rainfall over 30 years was 96 mm. Hence, the strike values need to be modified. In phase III, the strike of >125 mm rainfall occurred three times in 30 years (Figure 2). With respect to ERC/ERI, aggregate rainfall of four cumulative days was followed by AIC and two consecutive days by IFFCO–TOKYO while any two cumulative days for the remaining companies, which made difference in strike occurrence and payout. As water stagnation is a cumulative result of infiltration rate of rainfall into the soil profile, for deciding ERC, soil factor and intensity of rainfall during the critical stages of crops must be considered.

For Dharmapuri and Virudhunagar districts, CDD were covered only from 10 July to 10 September in the growing season. During that period, the strike S_1 to S_5 was considered as rainfall of < 2.5 mm occurred consecutively for 30 (S_1)/35 (S_2)/40 (S_3)/45 (S_4)/50 (S_5) days. In 25 years of evaluation, S_1 and S_4 occurred one and two times respectively, at Dharmapuri district. For Virudhunagar district, only S_4 occurred once in 26 years of evaluation.

For Coimbatore, CDD was covered only from 3 September to 31 October in the growing season. During that period, the strike S_1–S_5 was considered as rainfall of <2.5 mm occurred consecutively for 28 (S_1)/35 (S_2)/40 (S_3)/46 (S_4) and 48 (S_5). Only S_1 occurred once in 30 years of evaluation.

For Theni and Tirunelveli districts, DDI was covered under phase II. For Theni, the strike S_1 to S_4 was considered as rainfall of <2.5 mm occurred for 29 (S_1), 30–39 (S_2)/40–49 (S_3)/>50 (S_4) days. For Tirunelveli, S_1 condition remains the same as that of Theni. Remaining strike conditions were 30–44 (S_2)/45–54 (S_3)/>55 (S_4) days. No money was paid for S_1 condition. In Theni, S_2 occurred six times, while S_3 occurred five times. In

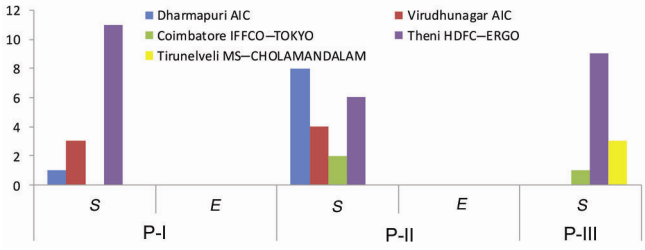

Figure 2. Comparison of strike events for excess rainfall cover/ excess rainfall index.

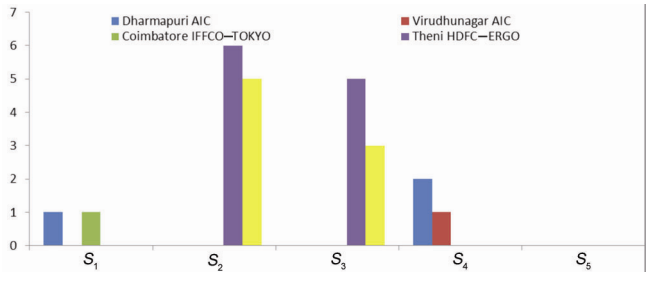

Figure 3. Comparison of strike events for consecutive dry days/dry days index.

Table 8. Hypothetical premium payment and compensation benefit by a farmer (Rs)

Weather perils	DRC/WDI	ERC/ERI	CDD/DDI	Total		Limited to 25 years	
				Premium	Payout	Premium	Payout
Dharmapuri	14,231	4,433	2,800	8,750	21,464	8,750	21,464
Virudhunagar	25,509	2,223	1,200	9,100	28,932	8,750	27,819
Coimbatore	3,129	472	160	10,500	3,761	8,750	3,134
Theni	6,652	10,074	16,000	9,507	32,726	7,923	27,272
Tirunelveli	2,087	1,294	7,000	10,500	10,381	8,750	8,650

Tirunelveli, S_2 occurred five times while S_3 occurred three times (Figure 3).

On comparison of CDD/DDI, among the different companies, cumulative days of the strike event were considered by AIC and IFFCO–TOKYO, whereas the strike events between particular days in the phase were considered in the remaining companies. With respect to DDI, HDFC–ERGO provides good compensation between particular days in the phase and this increased the payout benefit of the farmer. For CDD, the water holding capacity of the soil and the daily ET must be taken into account for fixing the strike threshold values as well as compensation rates.

Table 8 provides an examination of five districts covered by four agricultural insurance companies on hypothetical premium payment and amount of compensation received over 25 years. To arrive a good comparison among the different companies, the period is limited uniformly to 25 years.

The hypothetical premium payment and compensation analysis showed that farmers at Virudhunagar and Dharmapuri districts followed by Theni district were highly benefitted. The farmers in Coimbatore and Tirunelveli did not get adequate compensation compared to the above-mentioned districts. This was due to lower compensation rate per mm of rainfall fixed by the company. In this study, the deficit rainfall risk was more pronounced in all the study districts, whereas the risk of excess rainfall impact could be clearly observed in Theni district.

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Received 22 January 2014; revised accepted 21 October 2014

Zinc as an important factor determining resistance against *Helicoverpa armigera* herbivory in pigeon pea (*Cajanus cajan* L.)

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The potential of enzyme inhibitors against infestation of insects serves as attractive strategy for the management of devastating pests. In an effort to identify some effective and eco-friendly inhibitors of a damaging pest, *Helicoverpa armigera*, iron and zinc were found to be potent inhibitors of *H. armigera* α-amylase, which is an important digestive enzyme required for its survival. This observation motivated us to determine the status of iron and zinc in different pigeon pea genotypes in response to *H. armigera* herbivory. In general, there was significant decline in zinc content in developing seeds and pod wall after herbivory. However, zinc content was significantly higher in moderately resistant genotypes than moderately susceptible genotypes in infested developing seeds. Significant accumulation of iron was also observed in developing seeds of moderately resistant and intermediate genotypes after the pod borer attack. Higher content of zinc in pod wall of moderately resistant genotypes could determine their resistibility status against *H. armigera* herbivory.

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