Exploring cropping options with crop models: a case study of pigeonpea versus peanut in rainfed tracts of semiarid southern India

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Abstract

We have investigated the option of pigeonpea in place of peanut over rainfed tracts of semi-arid parts of southern India by analysis of the simulations with a crop model, APSIM At present, pigeonpea is cultivated as an intercrop with peanut and the yields are not high enough for economic viability. We have shown that the low yields are a consequence of late planting, which is adopted because it is fits in with the major crop peanut. The model results indicate that pigeonpea, when sown early, is an economically viable option to peanut.

Media Summary

Crop simulations using the APSIM model in southern India have indicated that pigeonpea when sown early is a viable option to peanut.

Introduction

Since the 70s, the major crop cultivated in the rainfed tracts of semi-arid parts of southern India is peanut. Generally the variety TMV2 of peanut is grown, and it is intercropped with pigeonpea. The peanut belt is characterized by low rainfall with large fluctuations from year to year. Since the soils are alfisols with low water holding capacity, this leads to large between-year variations in crop yield (Figure 1, for the Anantapur district). The current cropping system utilizes rainfall from late June onwards but the traditional cropping system was a complex one which used the rainfall in the pre-monsoon peak as well (Figure 2). When the current system was adopted in the 1970s the market price of peanut *vis a vis* the cost of production was high enough to ensure a reasonable profit in most years. However, with large tracts under the same crop for several years, various pests and diseases have now become endemic and their incidence has lead to a substantial reduction in peanut yield in recent years. Furthermore, in the last few years, the price of peanut has fluctuated a great deal (Gadgil et al., 2002) partly because of change in import policies of the government. Thus the farmers are interested in exploring alternate cropping strategies. Of particular importance is the potential of pigeonpea, which has been cultivated in this region for a long time over this region and is an important food crop.

We used the crop simulation model Agriculture Production Systems Simulator (APSIM, McCown et al., 1996) to simulate the variation in pigeonpea and peanut yields for the full range of planting dates at Bangalore and Anantapur, and estimated the expected relative profits.

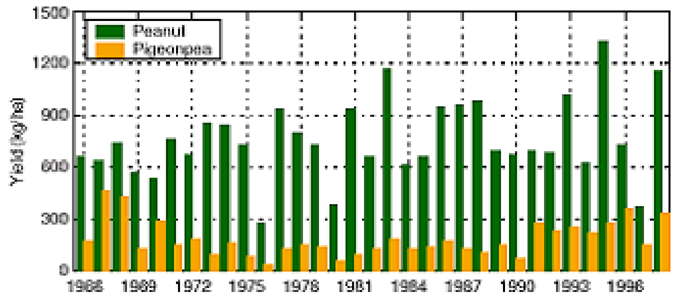

Figure 1. Observed variation of the average yield for Anantapur district of pigeonpea and peanut during 1966-98.

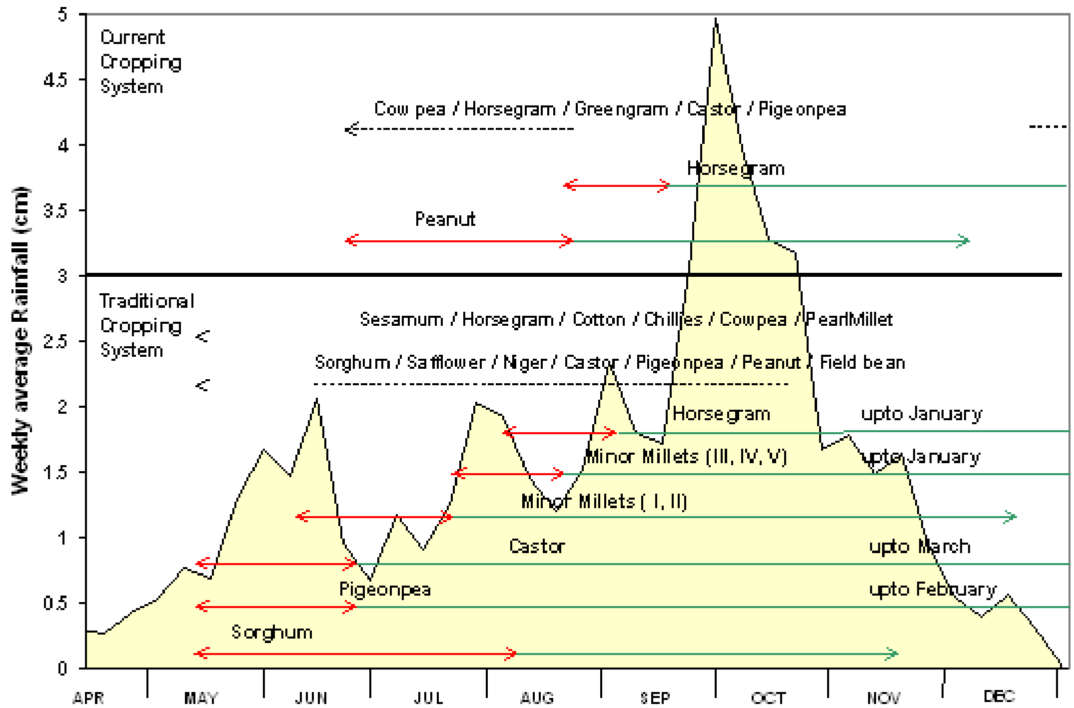

Figure 2: The planting windows (red line) and the growing season (from the last possible planting date) for each of the major crops cultivated traditionally and at present in the Anantapur region are shown. The crops cultivated as intercrops are also shown (dotted lines). The mean weekly rainfall (cm) at Anantapur is shown in the background.

Simulation of between-year variation of pigeonpea yield with the APSIM model

APSIM pigeonpea and peanut models (McCown et al., 1996) were available for this study. The parameters and relationships for pigeonpea were derived from 34 data sets derived from previously published studies in the literature (Carberry et al., 2001; Ranganathan et al., 2001; Robertson et al., 2001) and unpublished reports of the experiments conducted at ICRISAT-Patenchereu. For validation we used yield observations on the medium duration variety (TTB7) from routine varietal screening experiments conducted from 1991 to 2000 at the Main Research Station, G.K.V.K, University of Agricultural Sciences, Bangalore. It should be noted that the pigeonpea crop was protected from pests and diseases by appropriate plant protection measures. These observations were compared with the yield simulated with the APSIM model with the original parameter specifications (Figure 3). It can be seen that while the between-year variation was reasonably well captured, the amplitude of variation of the simulated yield was somewhat smaller, with lower than the observed yield in good yield years and higher than the observed in poor yield years.

The initial simulations indicated that the model was insufficiently sensitive to moisture stress associated with rainfed conditions in southern India. In the model, the sensitivity of the harvest index to moisture stress at the flowering stage depends upon the pair values specified for the parameter YPOT. Each of these two values, which determine the upper limits of the harvest index under zero and maximum moisture stress conditions, were specified in the original APSIM version to be 0.2, implying no sensitivity. However, Chauhan (1990) showed that moisture stress at this stage had a significant impact on the yield of pigeonpea, suggesting that different values for the two stress levels would be more appropriate. Further, Chauhan et al. (1987) showed that the harvest index could be as high as 0.32. Hence we increased the value corresponding to zero moisture stress to 0.3 and reduced that for maximum stress to 0.1. The simulation with this modification was more realistic (Figure 3). We found that the simulated crop carbon balance was close to the observations of Shankaralingappa (1997) for 1993 and 1995. The model also simulated well the time course in biomass accumulation and partitioning to leaves, stem and pods at all the stages of sampling. We also found excellent agreement between the simulated days to 50% flowering and maturity and the observations by Yadahalli (1992) for 1981/82.

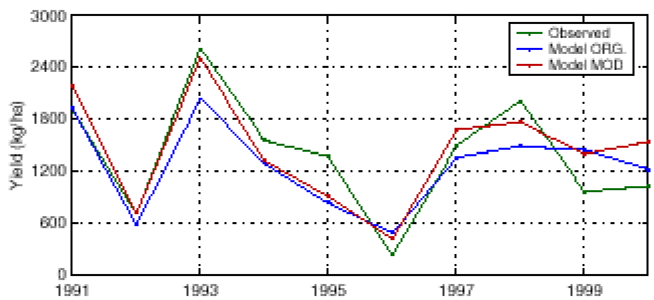

Figure 3: Observed variation of pigeonpea yield at UAS Bangalore during 1991-2000; the variation in the simulated yield with (ORG) and modified (MOD) APSIM models are also shown

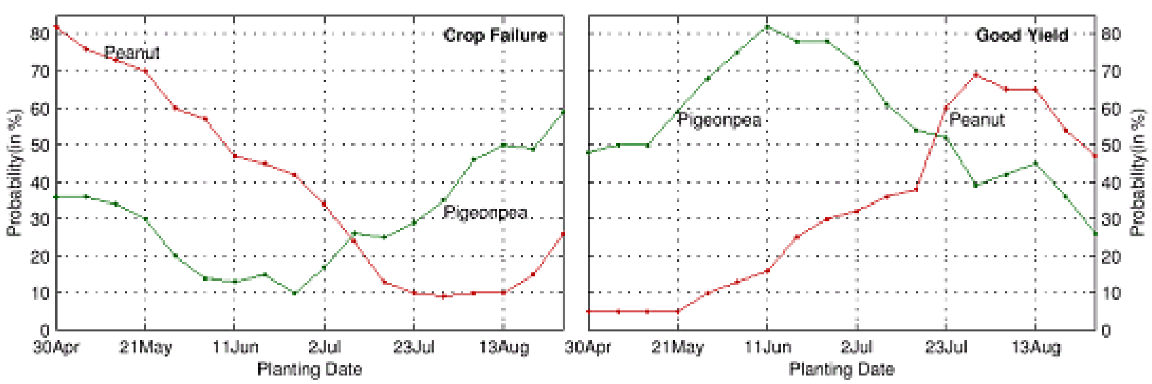

Figure 4: Variation with planting date of the probability of (a) crop failure and (b) good yields for pigeonpea and peanut at Anantapur.

Economic viability

At the present level of the costs of cultivation/hectare for peanut and pigeonpea and the prevailing market prices, yields below 500kg/ha for peanut and 400kg/ha for pigeonpea implies a net loss (Rao and Gadgil 1999). It is seen from Figure 1 that while production of peanut is profitable in some years, that of pigeonpea (which is grown as an intercrop) is not. Hence the area under cultivation of pigeonpea (relative to that under peanut) has steadily decreased from 9% in the 1970s to 3%. It appears that pigeonpea is grown for home consumption rather than for profit. So, it became necessary to investigate whether pigeonpea production can ever be profitable over this region, at least in some years, and if so whether there are strategies that are associated with it being more profitable than peanut. During the growing season in a semi-arid region such as this, wet spells are intermittent and separated by dry spells of varying duration. Hence there is a large variation of yield with planting dates because the life history stages at which the wet and dry spells occur vary with the planting date. When pigeonpea is cultivated as an intercrop, the planting date is chosen on the basis of what is considered appropriate for the major crop i.e. peanut. We investigated whether removing this constraint could improve the yields.

Variation of pigeonpea yield with planting date

We found that at Bangalore, where the probability of getting the required rainfall in any year is high, the pigeonpea yield generally decreased with delay in the planting date. At Anantapur, the variation was more complex, with late planting favoured in a few cases. In rainfed areas, the farmers plant within the specific planting window for the crop, as soon as adequate rainfall is received. In the case of peanut at Anantapur, the planting window is 22 June-17 August. Studies for Anantapur with the PNUTGRO model showed that the optimum planting dates are in the latter part of the planting window, from mid-July to mid-August (Gadgil et al. 2002). Simulations with validated APSIM-peanut model were consistent with this result. The probability derived from the simulations for 1911-98 for the two crops of (i) crop failure [yield less than 400 (500) kg/ha for pigeonpea (peanut)] and (ii) good yields [yield more than 600 (750) kg/ha for pigeonpea (peanut)] for different planting dates is shown in Figure 4. It is seen that the probability of crop failure is much higher for early planting dates for peanut and for late planting dates for pigeonpea. The probability of good yields (and higher profits) is high for late planting dates for peanut and for early planting dates for pigeonpea.

Conclusion

This study suggested that pigeonpea could be a viable option in the Anantapur region provided it is grown as a pure crop and the planting window is chosen as June. This recommendation is consistent with the traditional system (Figure 1), when the planting window for pigeonpea was a month earlier than the present one since it was not cultivated as an intercrop with peanut. The recommendation needs to be tested with experiments on farmers' fields as well as research stations.

Acknowledgments

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