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A REVIEW

Performance of *Kharif* crops as influenced by time of sowing in rainfed alfisols

C. RADHA KUMARI*, K.V.S. SUDHEER M. NIVEDITHA AND B. SAHADEVA REDDY
Agricultural Research Station (A.N.G.R.A.U.) ANANTAPURAM (A.P.) INDIA
(Email : radhaphd@yahoo.in)

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INTRODUCTION

The productivity of crops in rainfed conditions varies to a great deal from year to year, in response to the variability of climate and particularly the rainfall. One of the major challenges that confront is to minimise the fluctuations in crops yield due to aberrant weather conditions and to stabilise production at an acceptable level. Though the south west monsoon is a regular cyclic process over the Indian subcontinent, its behaviour is often erratic and also become extreme in the arid and semi-arid regions. Any deviation from normal in the seasonal behaviour of rainfall, *viz*., delay in the onset of monsoon, prolonged dryspells, excessive rains will have an adverse effect on crop growth and yield, finally the prospects of farmers. It is necessary to use the knowledge of climate variability to tailor the cropping pattern and the management practices for each of the agroclimatic zones.

Choice of right crops to suit the onset of monsoon is one of the most important crop production strategies that determine the success of cropping. Selecting the right crop along with the right time of sowing not only alleviates the adverse effects of moisture stress on crops, but also results in realizing profitable yields with lesser cost of production. The critical stages of the crop life cycle should coincide with the congenial conditions to produce its potential economic yield. Among various agronomic practices, sowing time plays a pivotal role, which intricates crop weather relationships. The spectacular variations observed in the optimum sowing time warrant the inquest for the pros and cons at different sowing dates for different crops, specific to the agro ecological situations.

In Andhra Pradesh rainfed groundnut is sown on varied times of sowing during *Kharif* season, depending on the time of the onset of monsoon, extending from middle of July to middle of August. Delayed sowing of groundnut beyond August invariably results in considerable reduction in yield even upto an extent of 70 per cent. This situation warrants to identify alternate remunerative crops to rainfed groundnut in alfisols.

* Author for correspondence

Contingent crop planning to avert the adverse conditions created due to delayed monsoon is an absolute strategy to gain on yields and minimizing production costs. The farmers in dryland areas are on eager outlook for the suggestions from farm scientists that give them a tangible solution to reap the best harvest by choosing a right crop and ideal sowing time. Therefore, literature pertaining to crop weather relationship and effect of time of sowing on crop growth, yield components and yield of different crops has been reviewed in this chapter.

Effect of climatic factors on crops :

Climatic factors such as temperature, solar radiation, relative humidity, sunshine hours, rainfall etc. play a dominant role on all aspects of crop growth and development.

Groundnut :

Temperature, above 30°C during pod development and maturity phases depressed the yield of groundnut (Varaprasad and Reddy, 1990). In pollachi tract of Tamil Nadu and at Tirupati of Andhra Pradesh, low night temperatures and high humidity favoured high pod setting (Vindhiyaverman and Raveendran, 1990 and Padmalatha, 1998). At Anantapur, an increase in mean relative humidity during pod filling phase from 47 to 58 per cent decreased the total dry matter production, but increased the partitioning of dry matter to pod (Padmalatha, 1998). Virender and Kandhola (2007) revealed that groundnut sown at onset of south-west monsoon rain, mean temperature during pod development phase showed significantly positive correlation with pod yield, whereas in second sowing crop (15 days after onset of south-west monsoon rain), minimum temperature at 50 per cent pod development phase and sunshine hours at pod development phase also had significant positive correlation with pod yield. Virendar *et al*. (2008) observed that in May sown crop under high temperatures significantly reduced dry matter production, partitioning of dry matter to pods and pod yield. Patel *et al*. (2010) revealed that during the years of dry spells, irrigations applied at 50 per cent ASM recorded greater pod yield than the crop grown under rainfed condition. In case of crop sown at onset of monsoon, mean temperature during pod development phase showed significant positive correlation with pod yield, whereas in second sowing crop, minimum temperature at 50 per cent pod development phase and sunshine hours at pod development phase also had significant positive correlation with pod yield. Regression models developed were able to account for 38 per cent variation in pod yield in crop sown at onset of monsoon and 85 to 92 per cent variation in crop sown 15 days after onset of monsoon. Guled *et al*. (2013) noticed that at Anand in middle Gujarat agro-climatic zone sowing of groundnut should be taken up for variety M-335 between 26th to 27th week, as a good rainfall amount and distribution of 823 to 852 mm under early/ normal onset of monsoon as observed during 2010 resulted in commercial production of groundnut. Whereas, sowing of groundnut should be taken up for variety GG-2 between 26^{th} to 27^{th}, because reasonably a good crop can be produced on as little as 269 to 298 mm of rainfall under late onset of monsoon as observed during 2009 crop growing season. However, during pod development phase (P_6) 79 per cent of mean relative humidity, 23.5 mm of Hg mean vapour pressure and 135 mm of rainfall amount were found optimum with an R_2 of 0.61, 0.54 and 0.63, respectively to have significantly influenced the pod yield. Similarly, the values beyond for mean maximum air temperature of 32.5 ^{0}C, evaporation rate of 3.2 mm and bright sunshine hours of 4.8 were found detrimental with an R_2 of 0.53, 0.77 and 0.59, respectively. The decrease in each unit of maximum air temperature, evaporation rate and BSS hours had resulted in decrease of 567, 332 and 474 kg ha^{-1} in pod yield levels.

Redgram :

Patel *et al*. (2000) reported that pigeonpea sown on the earliest date (30 June) attained the highest leaf area index (LAI), absorbed the largest amount of photosynthetically active radiation (PAR) and produced the highest total dry matter. The differences in biomass and seed yield among sowing dates were largely ascribed to totals of PAR absorbed and dry matter produced, especially in the reproductive phase. The high LAI persistence and PAR interception, coinciding with the podding phase, appeared to be mainly responsible for the increased yield in early sowings. Radiation use efficiency decreased as sowing was delayed, but did not have much effect on drymatter accumulation in various phases nor on final yields. Although the extinction coefficient was not influenced by sowing dates, it was inversely related to leaf area index in both cultivars GT-100 (determinate type) and BDN-2 (indeterminate type). Between the cultivars, the differences in biomass reflected the differences in PAR absorbed and drymatter accumulation, depending upon leaf area development and growth duration. The cultivar GT-100 had a higher seed yield and harvest index than BDN-2 due to more of the drymatter produced being partitioned into pods during the reproductive phase on account of its determinate growth habit. Early sowings of determinate cultivars could maximize both vegetative and reproductive growth, capture more light and produce more seed yields under rainfed conditions. Jayanna (2002) reported that irrespective of sowing dates, growing degree days increased continuously from 30th day after sowing to till harvest. There was an increase in GDD from 1 December to 15 January sowing. The highest GDD were recorded in 15 January sowing (1629) followed by 1 January (1507) sowing, 15 December (1479) and 1 December (1974) sowing. Ram *et al*. (2011) reported that pigeonpea sown on June 1 recorded the highest nodules/plant and nodule dry weight. Crop sown on May 15 accumulated 515 and 173 higher growing degree days (GDD) than crop sown on June 15 for 50 per cent flowering in 2005 and 2006, respectively. Similarly, crop sown on May 15 accumulated 322 and 278 higher GDD than June 15 sown crop for maturity in 2005 and 2006, respectively. May 15 sown crop produced significantly higher grain yield (10.3 and 35.0 % in 2005 and 15.6 and 18.9% in 2006, respectively) than June 1 and June 15 sown crop, respectively. Among the genotypes, AL 1507 produced the highest nodule number and dry weight of nodules/ plant. However, genotype AL 1492 gave significantly higher grain yield than all other genotypes and took maximum duration as well as growing degree days for flowering (50%) and maturity.

Castor :

Castor requires a moderately high temperature of 20 to 26°C with low humidity throughout the growing season to produce maximum yields. Long, clear sunny days are most suitable and cloudy or humid days irrespective of temperature will reduce yields. Very high temperature of 40°C or above at flowering, even for short period results in withering of flowers and poor seed set. High temperature can also adversely affect seed composition. Temperature above 30°C reduce oil and protein content and below 15°C reduce oil content and characteristics. The ratio between the male and female flowers being a varietal characteristic is strongly influenced by climate. High temperature favours male flowers and the low temperature favours femaleness. A seedbed temperature of 17°C is normally necessary for uniform germination. However, there are varietal differences to susceptibility at low seed bed temperature and subsequent emergence. As temperature cannot be manipulated easily under field conditions, seeding time can be so adjusted that the various physiological stages of crop can meet their optimum requirements during the growth cycle (Tewari and Singh, 1993 and 1995).

Sunflower :

Temperature governs seed filling during reproductive stage. Optimum temperature prevailed at flowering and pollination stages of July sown crop enhanced seed filling. Reddy and Giri (1996) found that the congenial weather prevailed during vegetative growth period was responsible for better growth of the sunflower crop. Differential response of sunflower in terms of yield attributing characters and final seed yields were due to the different temperatures coinciding with different phenophases of crop sown at different dates (Kathuria *et al.*,1996).

Effect of time of sowing on the performance of crops:

Groundnut :

Dhoble *et al.* (1990) revealed that delayed sowing beyond July decreased the pod yield drastically. Total number of pods plant^{-1}, filled pods plant^{-1}, hundred pod weight, hundred kernel weight, shelling percentage, pod yield and haulm yield recorded with July second fortnight sowing were distinctly higher than with October sowing. Suresh (1991) stated that maximum leaf area index with July-II fortnight sowing, when compared to delayed sowings. Progressive delay in sowing from July II fort night to October II fortnight significantly decreased the total dry matter production compared to its early date of sowing at all the stages of crop growth. Per cent decrease of total dry matter from July II fortnight sowing to October II fortnight sowing was 45.8, 37.5, 41.5 and 39.9 at 30, 60 and 90 DAS and at maturity, respectively. Padma *et al*. (1992) stated that groundnut sowings in the month of June recorded the highest hundred kernel weight, pod yield and oil yield than July and August sowings. Patel *et al.* (1993) observed significantly higher yield, when crop was sown during July first fortnight, which was superior to 28 June and later sowings beyond July second fortnight. Padhi (1994) observed the highest plant height with 20 June sowing, which was at par with 15 June and both of them were superior to 1 June sowing. June first sowing recorded the highest number of total and filled pods per plant, which consequently resulted in higher pod yield over June 15 and June 30 sowing. Similarly, the highest shelling percentage was recorded with June sowing. Significantly superior yield and highest harvest index were recorded with June I sowing, which was at par with June 15 sowing, but superior to June 20 sowing. Bhoite and Nimbalkar (1995) recorded significantly higher plant height at the normal onset of monsoon sowing, which was at par with sowing one week after onset of monsoon and significantly superior to sowing after 2 and 3 weeks after onset of monsoon. Mishra (1996) stated that sowing on 20 June increased pod yield significantly than sowing on 10 July and 20 July, but it was at par with sowing of 30 June. Chikkanna *et al*. (1996) observed that sowing of groundnut in July II fortnight recorded the highest dry matter accumulation and higher LAD at harvest, when compared with August I fortnight sowing. Kumar (1997) reported that plant height decreased gradually with delay in sowing from July second fortnight to August second fortnight. Significantly higher number of filled pods plant^{-1}, higher shelling percentage, test weight and higher pod yield were recorded with the earliest date of sowing of July second fortnight which decreased with each delay in sowing date upto August second fortnight (Kumar, 1997). Patel *et al*. (1998) recorded significantly superior yield, higher N, P and K uptake, when groundnut was sown on June first fortnight, which was at par with July first fortnight, but superior to July second fortnight sowing. Reddy and Reddy (2000) stated that crop sown on 28 May recorded the highest pod yield and delayed sowings in June, July and August reduced the pod yields. Chandrika *et al*. (2008) reported that crop sown during 1st fort night (I FN) of June recorded higher yield and yield attributes over the other two dates of sowing. Virendar *et al*. (2008) found the significant influence of sowing date on 100 kernel weight, shelling percentage and yield. Patel *et al*. (2010) revealed that groundnut crop sown at the onset of monsoon performed better than late sown crop sown 15 days after onset of monsoon rain and on an average, the early sowing gave 21.4 per cent higher pod yield. Sharma *et al*. (2013) noticed that delay in sowing from 25 April to 10 June reduced 100 kernel weight and oil content but marginally increased shelling out turn.

Green gram :

There was no significant difference in number of pods plant^{-1}, number of seeds pod^{-1}, thousand seed weight and seed yield when greengram was sown at November 1 and 16 in *Rabi* season (Nayak and Patra, 2000). Dhanjal *et al*. (2000) stated that sowing of greengram on 15 March recorded significantly higher number of seeds pod^{-1}, pods plant^{-1}, test weight and higher seed yield over the crop sown on 31 March and 16 April. Ram and Dixit (2000) reported that significantly the highest number of pods plant^{-1} and the highest grain yield were recorded with March 30 sowing than with March 20 and April 9 sowings. Highest N, P and K uptake was recorded with March 30 sowing, which was superior to March 20 and April 9 sowings. Yadav *et al*. (2014) noticed that the seed yield and harvest index and their contributing traits namely, number of pods plant^{-1}, pod length, number of seeds pod^{-1} and 1000 seed weight were decreased significantly as delayed the sowing from July 15 to August 1 and August 16. Awasarmal *et al*. (2015) concluded that the sowing of greengram during 25 MW (18 June) and 26 MW (26 June) were found beneficial as compared to other sowing times.

Redgram :

Padhi (1995) reported that there was no significant difference in number of pods plant^{-1} among sowing dates of redgram *i.e.*, 1, 15, 30 June and July 15. Higher number of branches plant^{-1} were recorded with June 1 sowing than with June 15, 30 and July 15 sowings. There was no significant difference among number of seeds per pod and test weight with different sowing dates from June 1, 15, 30 and July 15. Maximum seed yield was obtained when the crop was sown on June 1 and there was significant reduction in yield with delayed sowings and the lowest grain yield was recorded with 15 July sowing. The reduction in seed yield with every 15 days delay in sowing was 28.9, 36.7 and 70.3 per cent, respectively compared with June 1 sowing. Kumar (1997) reported that when redgram was sown on July 27, August 14 and August 22 there was no significant difference in plant height. Dry matter at harvest reduced significantly with delay in sowings and it was the highest with July 27 sowing followed by August 14 and August 22 sowings. When redgram was sown on July 27, there were maximum number of branches closely followed by August 14 sowing and both of them were at par with each other. August 22 sowing recorded the lowest number of branches which was at par with August 14 sowing. Higher seed yield was obtained when sowing was done in July first fortnight, which was at par with July second fortnight. Maximum pod number plant^{-1}, maximum number of seeds pod^{-1} and the highest test weight and seed yield was recorded with July 27 sowing, which was at par with August 14 sowing and significantly superior to August 22 sowing, which were at their lowest. Jayanna (2002) stated that higher dry matter accumulation was observed in 15 December (62.74 g plant^{-1}) and 1 December (58.29 g plant^{-1}) compared to 1 January (54.80 g plant^{-1}) during *Rabi* season. Kumar *et al*. (2008) reported lower plant growth and yield attributes in case of delayed sowing.

Castor :

Baby and Reddy (1998) reported that more number of spikes were recorded in early sown crop (June 15) than the late sown crop (June 30, July 15, 30 and August 18). Hundred seed weight was higher with June 15, July 15, July 30 sowings than with 18 August sowing. The highest seed yield was obtained when castor crop was sown on June 15. There was drastic reduction in yield with delay in sowing. However, 18 August sowing gave higher yield over 30 July sowing. Castor crop sown on August 15 recorded significantly higher number of capsules per spike than early (July 15) or late (September 15 and October 15) sown crop. The crop sown on September 1 produced distinctly higher dry matter production than with the late sown crop (Chauhan, 2001). Reddy (2002) revealed that sowing in July second fortnight recorded the highest plant height and dry matter production, which were significantly superior to later dates of sowing. Sowing of castor during July first fortnight recorded significantly higher number of capsules spike^{-1} and highest hundred seed weight when compared to the delayed sowings. Sowing during July first fortnight recorded significantly higher seed yield, which was at par with July second fortnight sowing, but significantly superior to August first fortnight and August second fortnight sowings. Srivastava and Chandra (2010) stated that early seeding of castor on 30th June and 15th July recorded significant increase in plant height, number of spikes/plant, spike length and number of capsules/spike as compared to delayed sowings. Similarly seed yield was also increased significantly with early sowings on 30th June and 15th July over delayed sowings on 30th July, 15th August and 30th August in both the years. With each delayed sowing after 15th July, there was significant reduction in seed yield and lowest yield was obtained when sowing was done on 30th August. Gross returns, net returns and B:C ratio were higher with sowing of 30th June and 15th July and delayed sowing on 30th August recorded negative net returns. Gowda *et al*. (2011) reported that early sowing of castor (May 30th) recorded significantly higher seed yield as compared to June 30th and July 30th sowings. Rani *et al*. (2014) reported that significantly highest castor bean yield was recorded with I F.N. of July sowing but it was at par with II F.N. of June sowing. Significantly lowest castor yield was recorded with I F.N of August sowing.

Sunflower :

Sudharani (1995) reported that sunflower crop sown on July 7 recorded significantly higher plant height throughout the crop growth than with the crop sown on 22 July and 7 August. Significant decrease in seed yield with delay in sowing from 7 July to 7 August. Sowing on 7 July recorded maximum seed yield followed by 22 July and 7 August sowings. July 7 sown crop registered maximum number of seeds head^{-1}, filled seeds head^{-1} followed by 22 July sown and 7 August sown crop. July 7 sown crop also recorded significantly higher test weight as compared to the crop sown on 22 July and 7 August. Reddy and Giri (1996) stated that, July sown crop recorded significantly higher LAI at all the stages as compared to the crop sown in August and September. There was significant difference between higher value of LAI with 14 July sown crop and 29 July sown crop. The lowest LAI was recorded when the crop was sown on 28 August. Sunflower sown in July accumulated higher dry matter plant^{-1}, compared to August and September sown crops, respectively. Reddy and Kumar (1996) stated higher dry matter accumulation by the crop sown in the first week of July might have resulted in better development of reproductive phase and produced better yield attributes, crop sown in the first week of July produced the largest flower head with the highest number of filled seeds, seed filling percentage, seed weight plant^{-1} and hundred seed weight. Delay in sowing from July to August and August to September significantly reduced levels of all the yield attributes. Badakh *et al.* (1996) reported that the seed harvested from the crop sown on 16 September recorded higher hundred seed weight. Bharud and Patil (1996a) concluded that the number of green leaves were consistently higher under timely sowing with onset of monsoon than with delayed sowings in *Kharif* season. Head diameter significantly larger in the crop sown on 7 July than with crop sown on 22 July and 7 August (Bharud and Patel, 1996b). Reddy and Giri (1997) reported that sowing of sunflower in July recorded the highest plant height, which gradually decrease with August and September sowings. Maximum plant height was observed with 14 July sown crop, while it was the lowest with 28 August sown crop. July sowing recorded significantly the highest number of filled seeds head^{-1}, seed filling percentage and seed yield followed by August and September sowings. Sowing of sunflower on 20 July produced the highest seed yield compared to 9 August sowing dates, due to favourable climatic conditions, which lead to better crop growth, yield attributes and seed yield (Dwivedi *et al.*, 1998). Sur and Sharma (1999) obtained the highest seed yield when crop was sown in the first fortnight of August. The yield was significantly lower when the sowing was done either before or later. Among all the dates of sowing tried, 14 July sown crop produced the highest yield (2.2 t ha^{-1}). The yield was found reduced progressively, when the crop was sown on 29 July, 13 August and 28 August. There was 66 per cent increase of seed yield when sown on 14 July as compared to 28 August sowing. Guravaiah (2002) reported highest dry matter accrual with 14 July sowing which was 5, 11 and 19 per cent higher than with the crop sown at 15 days delayed intervals from 29 July. The dry matter production decreased with delay in sowing. The highest seed yield was recorded with sowing in August first fortnight followed by first fortnight of September, first fortnight of October, second fortnight of August, second fortnight of October and second fortnight of July with significant disparity among them. There was no significant difference in oil content with 14 July and 29 July sown crops, which were significantly superior to that of 13 August and 28 August sowings. However, the difference between later two being at par. The oil content was found decreased gradually with delayed sowing. Khanday *et al*. (2002) found that crop sown on 25th April and 5th May recorded better yield compared to early sowing with concomitant increase in the yield attributes.

Clusterbean :

Sharma *et al*. (1993) revealed that sowing of clusterbean performed better under both dates of sowing *i.e.,* first fortnight and second fortnight of August under rainfed condition. Bhadoria and Chauhan (1994) reported that more number of clusters plant^{-1} was recorded with July first fortnight sowing than with July second fortnight and August first fortnight sowings. However, there was no significant difference among different sowing dates. There was no significant difference in number of pods plant^{-1} among sowing dates of July first, second and August first fortnights. The highest thousand seed weight was recorded with July first fortnight sowing and also resulted in maximum seed yield in all three years of study. Sowing beyond this period reduced the seed yield by 13.4 and 24.6 per cent, with July second fortnight and August first fortnight sowings, respectively. Modawi *et al*. (1995) reported that clusterbean sown in October produced significantly taller plants and higher dry weight than the crop sown in November and December. Taneja *et al*. (1995) reported hat more number of clusters plant^{-1} was recorded with July first fortnight sowing than with June first fortnight and July second fortnight sowings. Similar trend was also observed with respect to number of pods plant^{-1}. Significantly higher plant height with II fortnight of June than with the crop sown on 10 July and 30 July. Total number of branches plant^{-1} was higher with 20 June sowing than with 10 July and 30 July sowings. Sowing of cluster bean in June II fortnight recorded the highest dry matter per plant. The LAI was higher with June II fortnight and July I fortnight sowings, which was significantly superior to July II fortnight sowing. Sowing of clusterbean on July 6 produced significantly higher grain yield than the crop sown on July 20 and August 3. Jagtap *et al*. (2011) observed that clusterbean sown during 28th MW at 45 cm row spacing improved growth, yield attributes *viz.,* grain, straw and biological yield and increased productivity under agroclimatic conditions of Marathwada region. Kalyani (2012) revealed that growth parameters, yield attributes, yield and quality parameters were highest with RGM 112 sown during first fortnight of July, which was at par with HG 563 sown at the same time. Deka *et al*. (2015) noticed that sowing the crop on 1st July at a spacing of 45 x 30 cm produced the highest pod yield and the lowest pod yield was recorded in Aug 15th sowing with 45 x 45 cm spacing.

Studies on contingent cropping :

Dhoble *et al*. (1990) conducted an experiment at Parbhani to assess the performance of some crops under varying dates of planting under rainfed conditions. The results revealed that advanced dry sowing of different *Kharif* crops on 15 June and immediately after receipt of monsoon rains proved to be most advantageous, in respect of productivity and monetary returns. Sunflower, castor, pigeonpea and pearl millet, in the order, were identified the best for sowing in the first fortnight of July. For sowings in the second fortnight of July castor, pearl millet, pigeonpea and sunflower were preferred over other crops. Patel *et al*. (1993) conducted experiment on relative performance of different grain legumes under normal and late sown conditions and reported that among grain legumes, clusterbean, greengram, kidneybean and cowpea gave the highest seed yield. Late sowing had an adverse effect on yield. The yield reduction due to late seeding was 51.58, 59.24 and 74.13 per cent for kidneybean, greengram and cowpea, respectively. The yield of cluster bean remained unaffected. Thus, cluster bean could be an ideal crop for late sowing in contingency planning. Sawarkar and Thakur (1999) reported that castor and pigeonpea seemed to be more stable in yield for contingency cropping than other *Kharif* crops. Pigeonpea can be sown as late as 10 and 20 July and castor upto 30 July. Early sowing after the onset of monsoon *i.e*. 30th June was found ideal for sowing of all major *Kharif* crops. Among *Kharif* crops, pigeonpea was the most beneficial crop. A study conducted on contingent crop planning for rainfed alfisols revealed that during *Kharif* among the various crops tried as contingent crops for delayed sowing castor, redgram and groundnut sown during second fortnight of August gave the economic yields in the descending order of the yield reduction compared to their respective yields, if sown at right time. When sowing was delayed upto second fortnight of October, redgram gave higher yield than castor and other crops.

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