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Reproductive Performance of Cowpea (*Vigna unguiculata* (L.) Walp.) in Qassim, Saudi Arabia

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ABSTRACT. Pot and field trials were conducted during 1986 and 1987 growing seasons, respectively, to examine the factors responsible for the reduction in seed yield of cowpea which usually occurs for late planting dates in Qassim, Saudi Arabia. Cowpea cv CB5 was used in this study. The highest seed yield was attained from March planting date and decreased progressively with late planting. This reduction was the result of low number of flowers and low pod set. Reductions in number of seeds per pod and set was attributed to lack of fertilization which resulted from male sterility. Male sterility was caused by anther indehiscence and low pollen viability. These adverse effects appeared to be associated with the higher temperatures which were found at later planting dates.

Cowpea is one of the most stable warm season food and fodder crops due to its nutritional value and drought tolerance (Hall *et al.* 1979). However, the high temperatures prevailing during the summer in Saudi Arabia causes considerable yield losses of this warm season crop (Annual Report 1983/84).

Researchers have indicated that the reduction in yield of cowpeas at high temperatures could be attributed to a reduced number of reproductive nodes (Warrag and Hall 1984a), peduncle abortion (Stewart *et al.* 1980) and/or excessive flower abscission (Warrag and Hall 1984b). However, in these studies plants were grown in pots under controlled environment and were subjected to square wave thermal regimes, a situation which does not occur in the field. Nielsen and Hall (1985) studied the performance of cowpea plants in the field, but the average daily maximum air temperatures during their experiment was very low compared with summer temperatures in Saudi Arabia.

This study was conducted to determine the components responsible for the reduction in seed yield of cowpea due to delayed planting in Qassim, Saudi Arabia.

Materials and Methods

The experiments were conducted near Buriedah, Qassim, Saudi Arabia (26° 5,N 44°E, 725 m above sea level) on an alkaline sandy loam soil containing 86.6% sand, 0.4% silt and 13.0% clay. Average daily minimum and maximum air temperatures during the growing period for 1986, 1987 and the last twenty years were obtained from a nearby meteorological station (Table 1).

Table 1. Mean daily minimum and maximum air temperature (°C) during the growing season of cowpea at Buriedah, Qassim, Saudi Arabia

Month	1986		1987		1967-1986	
	Mean minimum	Mean maximum	Mean minimum	Mean maximum	Mean minimum	Mean maximum
February	–	–	8.0	26.4	4.5	22.4
March	13.0	27.5	11.5	27.0	8.2	30.5
April	16.2	29.5	16.7	33.2	12.9	34.8
May	21.5	36.3	22.3	39.3	18.6	39.4
June	22.6	41.8	23.3	41.0	21.8	42.2
July	23.9	41.5	26.5	44.9	23.0	42.8
August	25.5	43.3	26.5	43.7	22.7	42.8
September	22.0	39.0	22.8	42.1	19.6	41.4
October	20.3	37.5	19.4	34.9	14.6	36.4

Cowpea (*Vigna unguiculata* (L.) Walp.) cv, California Blackeye No. 5 (CB5), known locally as "Sunaawi" was used for this study since it is the most commonly grown cv in Qassim region, and is also widely used as a parent in breeding programs (Nielsen and Hall 1985). At sowing the seeds were inoculated with peatbased rhizobia (El type, Nitragin Co., U.S.A.).

Experiment 1

This experiment consisted of four planting dates, starting during the first week of March, 1986, at monthly intervals. Three seeds were sown 2.5 cm deep in each 40 liter plastic pot filled with surface soil. Seedlings were thinned to one per pot at the expansion of the third trifoliate leaf. Plants were irrigated whenever the tensiometers placed in the pots indicated 20 centibars. Half strength Hoagland's solution was used for watering alternately with tap water.

The experimental design was a randomized complete block with four replications. Each replication was represented by two pots. One pot from each replicate was used for destructive studies.

Experiment 2

A field experiment was conducted in the College of Agriculture Research Farm, Buriedah, during 1987. The treatments consisted of six planting dates with monthly intervals, with first planting date on February, 13. Seeds were sown 2.5 cm deep on flat. The plant spacing was 50 and 10 cm between and within rows, respectively. The experimental design was a randomized complete block with four replications. Each plot measured 2.5 m wide and 5.0 m long.

Prior to sowing, 100 kg P, 100 kg K and 50 kg N ha^{-1} were incorporated in the soil as triplephosphate, potassium sulphate, and urea, respectively. At floral bud formation 100 kg N ha^{-1} were applied as urea. Plants were well-watered using a central pivot irrigation system. Weed control was done by hand as necessary.

Observations and Measurements

Dates at which 50% of the plants had macroscopic floral buds, open flowers and mature pods were recorded and the phase lengths between these dates were calculated for each treatment. Open flowers of one plant, and on one meter of row, were counted for each replicate in experiments 1 and 2, respectively, to determine the percentage pod set (number of pods × 100/number of flowers produced). Every other day, during anthesis, open flowers were collected from other plants. The pistils were removed from these flowers then fixed in FAA (85 ethyl alcohol (70%): 10 formaldehyde (40%): 5 glacial acetic acid) for two days, rinsed with distilled water and softened in 8N Na OH aqueous solution. After one day the styles were placed in a few drops of acetocarmine on glass slides. A cover slip was put on each slide and pressed gently to crush the tissues. The slides were then examined under a light microscope and the percentage of flowers with pollen grains on their stigmas were determined. In addition, the androecia were examined under a dissecting microscope to determine the percentage of flowers with only dehiscent anthers, and the percentage of flowers with only indehiscent anthers. Some pollen grains were stained with lactophenol-cotton blue and examined under a light microscope to estimate pollen viability (Stanley and Linskens 1974). The viable pollen grains would stain deep blue, whereas the nonviable ones would not stain.

The undisturbed plants in experiment 1, and the plants in the two middle meters in experiment 2, were cut when more than 95% of the pods had become dry. The numbers of pods were recorded. Seeds were then removed from the pods, dried in bell jars containing silica gel, and the number of seeds per pod, weight of 100 seeds and total seed yield were determined.

Results and Discussion

In both 1986 and 1987 the average daily maximum and minimum air temperatures increased gradually from February to reach the peak in July and August (Table 1). The same trend was also followed by the average temperature of the last twenty years (1967-1986).

The emergence of the seedlings was slow for the first planting date, then it was progressively faster at the later dates (Table 2). This was probably due to the cool weather prevailing during the early growing period. In 1987, the February planting date seedlings were stunted and necrotic, and some of them were missing resulting in a lower plant density per unit area. Similar results were reported by Warrag and Hall (1984a) with the same cultivar grown in a growth chamber at 27, 19 and 19°C day air, night air and soil temperatures, respectively.

Table 2. Number of days from sowing to various developmental stages of cowpea cv CB5

Planting date	Days to emergence	Days to floral bud formation	Days to anthesis	Days to pod maturity
Experiment 1:*				
March	7	38	48	70
April	4	34	45	67
May	3	27	40	56
June	3	36	46	61
L.S.D. 5%	1.1	4.8	2.2	3.3
*Experiment** 2:*				
February	12	44	60	84
March	10	39	52	74
April	7	29	39	59
May	5	33	43	60
June	5	41	64	79
July	4	42	61	75
L.S.D. 5%	1.5	6.5	5.9	6.1

* Pot experiment in 1986.
** Field experiment in 1987.

The number of days from sowing to the appearance of floral buds and to anthesis decreased and then increased again with later planting in both experiments (Table 2). The increase in the rate of emergence partially accounted for the decrease in number of days to budding and anthesis, but the decrease in time needed to accumulate sufficient number of heat units was probably the major factor (Hadley *et al.* 1983). The delay in floral bud formation and anthesis of plants sown in June in experiment 1, and for those sown in May, June and July in experiment 2, might be due to an increase in sensitivity of plants to day length at extremely high temperatures (Wallace and Enriquez 1980, and Daw El-madina and Hall 1986), prevailing during these months. Although the time from sowing to pod maturity followed the same trend as budding (Table 2), the time from anthesis to pod maturity decreased with later planting due to the increase in temperature which was in accordance with the results of Wein and Ackah (1978) and Nielsen and Hall (1985).

Significantly less flowers were produced from June and July plantings compared to the others (Table 3) in both experiments. The differences in the numbers of flowers produced by the planting dates earlier than June were not

Table 3. Floral characteristics at anthesis of cowpea cv CB5

Planting date	No.* of flowers	Flowers with no pollen on stigma (%)	Flowers with only dehiscent anthers (%)	Flowers with only indehiscent anthers (%)	Viable pollen grains (%)
*Experiment** 1:*					
March	38	0	90	0	90
April	36	5	83	4	81
May	34	17	65	16	59
June	25	24	39	38	37
L.S.D. 5%	4.8	5.1	8.1	4.4	4.9
*Experiment*** 2:*					
February	128	5	98	0	92
March	139	5	93	0	91
April	126	14	50	7	86
May	129	29	43	19	54
June	70	78	22	54	42
July	67	82	13	67	18
L.S.D. 5%	5.9	5.3	5.2	4.5	5.7

* Per plant in experiment I and per m^2 in experiment 2.

** Pot experiment in 1986.

*** Field experiment in 1987.

statistically significant, except the March planting date in experiment 2. These results might indicate that the number of flowers produced was not affected by moderately high temperatures, but it may have been substantially reduced by extremely high temperatures which prevailed during July and August. The significant reduction in the number of flowers produced from planting in June and July was probably due to the high number of aborted peduncles and inhibition of floral bud formation (Dow El Madina and Hall, 1986).

Examining flowers at anthesis revealed that a significant percentage of the flowers produced from late planting dates had no pollen grains on their stigmas (Table 3). This was associated with low and high percentages of flowers with dehiscent and indehiscent anthers, respectively. Using the same cultivar, Warrag and Hall (1984b) reported similar results when plants were subjected to high night air temperatures. Pollen viability also decreased progressively with delay in planting date (Table 3). Viable pollen grains were round, were about 80 μm in diameter, and had easily detected germpores, whereas the inviable pollen grains were smaller and irregular in shape. Reductions in pollen viability due to high temperatures were also reported for other crops such as common beans (Dickson and Boethger 1984), tomato (El Ahmadi and Stevens 1979) and wheat (Saini and Aspinall 1982).

Not all flowers which reach anthesis developed into pods. The percentage pod set at early dates was within the normal range reported with cowpea (Ojehomon 1970) and then decreased progressively with later plantings (Table 4). The number of pods followed the same trend. The reduction in number of pods was due to a slight reduction in percentage pod set from April and May planting dates and substantial reduction of both number of flowers and percentage pod set from later planting dates (Tables 3,4). Such reduction in percentage pod set had been observed by Nielsen and Hall (1985) with the same cultivar under high night air temperatures.

The low pod set from late planting dates was, apparently, due to a lack of flower fertilization which resulted from male sterility. Male sterility was attributed to anther indehiscence and low pollen viability at anthesis. Similar findings were reported with other cowpea cultivars (Warrag and Hall 1983) and some tomato cultivars (El Ahmadi and Stevens 1979) under high thermal regimes.

The number of seeds per pod and seed weight decreased slightly as planting date was delayed (Table 4). Such reductions have been reported to be associated with the length of time from anthesis to pod maturity (Wein and Ackah 1978).

Maxmimum seed yield was attained by March planting date and decreased substantially with delay of planting (Table 4). The reduction in pod set accounted for the low seed yield of April and May planting dates, whereas the reduction in

Table 4. Yield and yield components of cowpea cv CB5

Planting date	No.* of pods	Pod set %	No.* of seeds per pod	Weight of 100 seeds (g)	Seed* yield (g)
*Experiment*** 1:*					
March	25	66	5.6	20.7	28.4
April	21	59	5.5	20.3	23.8
May	14	41	5.0	19.7	15.2
June	6	22	4.8	18.3	5.0
L.S.D. 5%	3.2	7.4	0.5	0.8	4.2
*Experiment**** 2:*					
February	63	49	5.8	20.8	76.3
March	74	54	6.2	21.7	99.1
April	42	34	5.2	20.5	44.8
May	19	15	4.0	19.7	15.0
June	12	17	3.8	20.2	9.2
July	6	9	4.3	17.4	4.4
L.S.D. 5%	6.4	7.7	0.5	0.8	10.4

* Per plant in experiment 1 and per m^2 in experiment 2.
** Pot experiment in 1986.
*** Field experiment in 1987.

both number of flowers and pod set accounted largely for the extremely low seed yield from later plantings. On the other hand the reductions in number of seeds per pod and seed weight were too small and therefore had a minor effect on seed yield (Table 4). The reduction of seed yield from the earliest planting in 1987 was due to a lower number of flowers (Tables 3,4) possibly resulting from cool weather during early plant growth.

The onset of flowering and pod set of the plants sown in April and May coincided with moderately high temperatures, whereas that of the plants sown in June and July coincided with extremely high temperatures (Tables 1,2) indicating a positive relationship between high tempeature during reproductive growth and poor seed yield of cowpea. Adverse effects of high temperature during reproductive growth on seed yield of cowpea have been reported in few other studies (Summerfield *et al.* 1979; and Nielsen and Hall 1985). To obtain high seed yield, therefore, cowpea should be sown as early as March in Qassim area. However, for continuous supply of fresh cowpea pods during summer, it is essential to have a genotype which has both high yield and good pod setting ability during summer. Such a genotype can be developed by the incorporation of heat tolerance from appropriate cultivars, such as Prima and TVu 4552 (Warrag and Hall 1983) into high yielding cultivars such as CB5 (Nielsen and Hall 1985).

Conclusions

The number of days from sowing to different phenological phases of cowpea cv CB5 decreased due to delay in planting date, and increased again as planting date was delayed further. This was possibly due to very low and extremely high temperatures at the earliest and very late planting dates, respectively.

Cowpea CB5 gave the highest seed yield when sown in March at Qassim. February sowing in 1987 resulted in a lowered seed yield possibly due to the cool weather prevailing during February and March which resulted in a lower number of flowers produced per unit area. The plants sown after April produced significantly progressively lower seed yield. The yield component most affected by late plantings, and consequently high temperature during reproductive growth was pod set. The number of flowers was much reduced from very late plantings when the temperature at flowering was extremely high. Reduced pod set and lowered flower number were responsible for much of the reduction in seed yield from later plantings. The reduction in pod set was due to a lack of fertilization resulting from anther indehiscence and low pollen viability. The reduction in seeds per pod and seed weight had a minor effect in reducing seed yield as planting date was delayed.

To obtain high seed yield, growers in the Qassim area are advised to sow cowpea as early as March. However, since most of the consumers in this region prefer to use fresh cowpea pods, a high yielding cultivar during summer should be searched for.

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النمو الثمري لمحصول اللوبيا بمنطقة القصيم بالمملكة العربية السعودية

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المملكة العربية السعودية

تمت زراعة صنف اللوبيا "CB5" المعروف محلياً بالإسم «صنعاوى» في مواعيد مختلفة خلال عامي ١٩٨٦م و١٩٨٧م. أدت الزراعة في مارس إلى أعلى إنتاجية في محصول الحبوب ثم أنخفضت الإنتاجية في استطراد كلما تأخر ميعاد الزراعة. يرجع هذا الإنخفاض أساساً إلى الإنخفاض في عدد الأزهار المتفتحة ونسبة القرون العاقدة بينما كان للانخفاض في عدد الحبوب في القرن ووزن الحبة أثر طفيف. يعزى انخفاض نسبة القرون العاقدة إلى العقم الذكرى الناتج عن عدم انفتاح نسبة كبيرة من المتك وانخفاض حيوية حبوب اللقاح. الارتفاع المطرد في درجة الحرارة كلما تأخر ميعاد الزراعة، ربما، هو العامل الرئيسي الذي أدى إلى هذه التأثيرات.