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Influence of weather sequence on rabi jowar crop yield at Solapur

(SMT.) N. N. KHAMBETE and S. VENKATARAMAN

Meteorological Office, Pune

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ABSTRACT. The variations in the grain and fodder yield of M-35-1 jowar in sowing date trials at Solapur in two typical rainfall years are examined from the meteorological standpoint. The temperature regimes in the vegetative and flowering phases, moisture accretion at or near crop emergence, rainfall incidence in the vegetative crop phase and soil moisture storage, emerge as the factors chiefly affecting ear development, intitial crop stand, fodder yield and grain out-turn respectively. The final yield is a result of the interplay of the above effects. More such multi-location studies appear warranted.

1. Introduction

The traditional agricultural practice in the dryland rabi tracts of Maharashtra has been to sow jowar or wheat in mid and late October respectively. The time of wheat sowing is justified from the point of view of realisation of more congenial temperature regimes. However, October sowings of jowar is, *a priori*, not justified, as considerable fraction of September rainfall, which a standing crop can use, will be lost as evaporation and run-off over bare soil. Hence, reports of jowar sown in the beginning of September, giving 100 per cent more yield in these tracts than the traditional October sowings (Rao 1971) are not surprising.

However, even with advanced September sowings, there are variations in the grain and straw yields of jowar, from year to year, at the same location and in the same year from location to location, in this tract and in areas adjoining it. Study of the role of weather in these variations seems to be limited (Rana *et al.* 1972, Rao *et al.* 1975).

An understanding of the ecological reasons for variations in yield at a centre due to variations in times of sowing could be helpful in evaluating the spatial and time variations in jowar crop yields, due to weather vagaries. Hence, the present study relating to rabi jowar was undertaken.

2. Material and method

In the dry land rabi jowar tracts of Maharashtra the variety M-35-1 is still popular. Hence, the data on the yield of grain and fodder of M-35-1 jowar recorded in sowing date trials at Solapur (with the period of sowing extending from late August to late October), in the years 1971-72 and 1973-74 was taken up for examination (Table 1). It may be mentioned here that the year 1971-72 had a lesser and poorer distribution of rainfall than 1973-74.

To understand the reasons for the yield variations the daily maximum and minimum temperatures at Solapur for crop seasons of 1971-72 and 1973-74 were collected. For the different sowing dates in 1973 the total accumulation of mean daily temperatures above a base temperature of 4°C in the period from the date of sowing to 50 per cent flowering were worked out (Table 3). Using the above heat summation information, the dates of 50 per cent flowering which were not recorded in 1971 were estimated for different sowing dates (Table 3). As the day to day variations in minimum temperature are more marked in the later half of the crop season than the maximum temperature, the mean and minimum temperature during the period of panicle initiation (average of 22 to 27 days prior to 50 per cent flowering) and during flowering average of ($\pm$4 days of 50 per cent flowering) were computed (Table 3).

Soil moisture storage (SMS) from daily falls of rain as per the method of Venkataraman *et al.* (1973) were worked out (Table 2) for the following periods/crop phases, *viz.*, (*a*) 1 June to the date of sowing, (*b*) 4, 3, 2, 1 weeks prior to the date of sowing, (*c*) during the period of germination, *i.e.*, 10 days from the date of sowing, (*d*) from completion germination to about a month later and (*e*) for the rest of the crop life period. The rainfall amounts for the above periods were also tabulated alongside the SMS values (Table 2). To examine the relative influence of soil moisture storage and yield the following data were incorporated in Table 1, *viz.*, (*i*) soil moisture storage in the period two weeks prior to sowing and during germination (A), (*ii*) soil moisture availability in the period upto two weeks from sowing (B) and (*iii*) rainfall amounts in the vegetative crop phase(C).

TABLE 1

Yield of jowar (M-35-1) in sowing trials

Date of sowing	Soil moisture storage: Two weeks prior to date of sowing and during germination (A) (mm)	Soil moisture storage: From June to two weeks prior to date of sowing (B) (mm)	50% flowering: Date	50% flowering: No. of days	Total rainfall (mm) from completion of germination to 50% flowering (C) (mm)	Yield in Q/H: Grain	Yield in Q/H: Straw
			1971-1972				
8 Sep 71	81	27			246	8·83	57·00
20 Sep 71	47	102			108	5·38	36·14
7 Oct 71	54	103			18	4·24	17·51
23 Oct 71	2	156			0	1·53	7·58
			1973-1974				
25 Aug 73	13	116	7 Nov 73	75	408	19·10	119·44
14 Sep 73	32	129	28 Nov 73	75	377	25·07	80·56
2 Oct 73	98	129	22 Dec 73	83	129	17·64	44·44
22 Oct 73	72	179	1 Jan 74	72	0	8·22	37·50

TABLE 2

Accumulated soil moisture storage and total rainfall (in parenthesis in mm) in various periods/crop phases

Date of sowing	From 1 June to date of sowing	In specified weeks prior to date of sowing: 4	3	2	1	Germination	Completion of germination*	Elongation
08 Sep 71	102 (309)	86 (205)	86 (203)	81 (164)	0 (5)	0 (0)	54 (228)	2 (18)
20 Sep 71	102 (309)	86 (203)	0 (5)	0 (0)	0 (0)	47 (138)	8 (108)	0 (0)
07 Oct 71	150 (486)	47 (178)	47 (178)	47 (156)	6 (39)	1 (51)	2 (18)	0 (0)
23 Oct 71	158 (555)	56 (246)	8 (108)	2 (69)	0 (18)	0 (0)	0 (0)	0 (0)
25 Aug 73	129 (491)	45 (204)	18 (124)	13 (87)	0 (33)	0 (7)	32 (97)	89 (311)
14 Sep 73	129 (505)	9 (79)	0 (29)	0 (11)	0 (8)	32 (89)	65 (209)	24 (102)
02 Oct 73	161 (610)	32 (113)	32 (106)	32 (105)	0 (16)	64 (168)	25 (129)	0 (0)
22 Oct 73	226 (804)	65 (209)	65 (209)	47 (129)	1 (27)	24 (102)	0 (0)	0 (0)

* Completion of germination till commencement of elongation

3. Main features

The following main features emerge from Table 1: (*i*) In 1973, the time taken for the crop to reach the 50 per cent flowering stage is nearly the same in all sowing dates except for the early October sowing which is more, (*ii*) Generally both grain and straw yield decrease with delayed sowings, the reduction in latter being more drastic than the former and

TABLE 3

Temperature (°C) regimes in crop-phases

Date of sowing	Date of 50% flowering	$\Sigma\left(\frac{\text{Temperature °C Max.}+\text{Min.}-4°C}{2}\right)$ from 1 to 2	Average of daily mean temp. from 22-27 days prior to 50% flowering	Average of mean temp. during flowering (±4 days of 50% flowering)	Average of Min. from 22-27 days prior to 50% flowering	Average of Min. temp. during flowering (±4 days of 50% flowering)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
25 Aug 73	07 Nov 73	1583	25·3	22·7	19·0	15·1
14 Sep 73	28 Nov 73	1545	24·2	21·2	17·0	14·5
02 Oct 73	22 Dec 73	1568	21·1	21·9	11·8	15·7
22 Oct 73	01 Jan 74	1303	22·9	20·2	14·6	11·3
08 Sep 71	21 Nov 71	1567	24·1	21·9	17·8	14·0
20 Sep 71	08 Dec 71	1576	22·1	20·1	13·5	11·0
07 Oct 71	31 Dec 71	1566	20·3	20·0	11·3	10·4
23 Oct 71	06 Jan 72	1308	20·4	20·7	11·9	10·6

(*iii*) The lowest grain yield in 1973 of late October sowing which is comparable to the highest grain yield in September sowing of 1971 assumes an ecological significance.

In the next paragraph the main features are analysed and discussed.

4. Discussion

4.1. *Influence of temperature and rainfall on crop phases*

4.1.1. *Flowering* — The temperature accumulation for the period from sowing to 50 per cent flowering is about 1560 day degrees above a base mean daily temperature of 4°C for the first three dates of sowing in 1973. However, for the last sowing it is about 1300 day degrees only. The indications from Table 3 are that minimum temperature below 14°C during the flowering period and the mean temperature below 21°C during panicle initiation would lower the potential grain yield. However, the above temperature limits and the reduction in heat summation in the late October sowing would need further study.

4.1.2. *Vegetative growth* — Rainfall during vegetative period appears to be highly beneficial for elongation of jowar. This result is seen prominently by arranging Table 1 in the following form of decreasing rainfall in the vegetative period (Table 4). A regression analysis of the factors, A, B, C on straw yield (Table 4) shows that 'C' significantly influences the straw yield.

4.1.3. *Significance of factors A, B, C to grain yield* — It would appear from above that the soil moisture recharge just preceding sowing and/or during germination exerts an effect through its influence on initial density of crop stand. Soil moisture adequacy rather than rainfall incidence influences the grain yield. The regression analysis of A, B, C on grain yield shows that factors individually influence but their total influence is highly significant.

TABLE 4

Yield and A, B, C factors

Date of sowing	A	B	C	Straw yield	Grain yield
25 Aug 73	13	106	408	119	19
14 Sep 73	32	129	311	81	25
08 Sep 71	81	21	246	57	8·8
02 Oct 73	98	129	129	44	18
20 Sep 71	47	102	108	36	5·4
07 Oct 71	54	013	18	17·5	4·2
22 Oct 73	72	179	0	37	8·2
25 Oct 71	2	156	0	7·6	1·5

4.2. *Grain yield—Comparative studies*

4.2.1. *8 September 1971 versus 22 October 1973 sowing* — Table 1 shows that the soil moisture storage in period from two weeks prior to sowing and completion of germination is 81 and 72 mm respectively, in 1971 and 1973. The 1971 crop had received 246 mm of rain during its vegetative phase besides the 21 mm SMS in the period preceding two weeks before sowing. The 1973 crop on the other hand, could draw on a soil moisture storage of 179 mm but had no rains during vegetative phase. Thus, the total quantum of moisture availability for the two crops for reaching maturity would have been adequate. It would appear that full grain yield potential in the early September sowings may not be realised if the soil moisture storage is poor while very good soil moisture reserves are needed for realising even a moderate grain yield potential in October sowings.

TABLE 5

Correlation of yield and A, B, C factors

Yield	Correlation coefficient (C.C.)			Multiple C.C.	Percentage contribution of		
	A	B	C		A	B	C
Grain	0.084	0.162	0.772	0.89	2.9	6.4	69.6
Straw	—.182	—.001	0.949*	0.96**	1.0	0.1	93.9

Regression equation for grain yield:

$$Y = -7.004 + 0.090A + 0.057B + 0.050C$$

Regression equation for straw yield:

$$Y = 0.751 + 0.054A + 0.108B + 0.231C$$

A : Soil moisture storage in mm during 2 weeks prior to date of sowing and germination.

B : Soil moisture storage in mm during 1st June to two weeks prior to date of sowing.

C : Total rainfall in mm from completion of germination to 50% flowering.

4.2.2. *20 September 1971 versus 7 October 1971 sowing* — The 20 September 1971 and 7 October 1971 crops had nearly the same SMS in periods A and B. The 20 September crop received about 100 mm more of rainfall in vegetative phase compared to about 20 mm of the October crop. However, the poorer rainfall in the vegetative phase of the October sown crop resulted in the grain yield being reduced by 20 per cent only.

4.2.3. *23 October 1971 versus 22 October 1973 sowing* — In the October sowings of 1971 and 1973 there was no rain in period C. The soil moisture storage in period A was much less in 1971 while in period B storage though less in 1971 was comparable to that of 1973. Thus lower grain and straw yield in 1971 must be due to poor initial stand of crop.

4.2.4. *25 August versus 14 September sowing 1973* — The 25 August sown crop had much less soil moisture storage in period A compared to that of 14 September sowings. The 14 September sown crop had nearly as much SMS in period B as the August crop. Both crops had more than adequate rainfall in period C. Because of the improved SMS in period A, the 14 September crop would have had a better initial stand.

4.2.5. *2 October 1973 sowing* — For the 2 October 1973 crop the soil moisture regime in period A was better than those of the previous two sowings, while the SMS in period 'B' was comparable to earlier two sowings. The crop had only 129 mm of rainfall in the vegetative growth period. The grain yield of the 2 October sowing was comparable to the 25 August sowing despite a heavy reduction in straw yield.

5. Conclusions

From the above study the following inferences emerge :

5.1. Jowar variety M-35-1 appears to be thermoneutral regarding vegetative development. However, the reduction in heat summation in late October sowings requires more study.

5.2. The mean daily temperature regime during panicle initiation and the minimum temperature regime during flowering appear to have a bearing on grain yield.

5.3. The minimum temperature at Solapur normally goes down below 15° C by third week of November. As M-35-1 takes about 70 days to flower and the grain yield appears to go down when average minimum temperature during flowering 14°C it would be necessary to sow this crop in the beginning of September. This period is also suitable from the moisture and rainfall point of view.

5.4. Rainfall in the period two weeks prior to sowing and/or during germination and adequate SMS in the vegetative period appears essential for realising a good grain yield.

5.5. Rainfall during the vegetative phase exerts a physical influence on better and taller growth of M-35-1 and leads to increase straw yield. Thus in case of drawf hybrids a better latitude in sowing date regarding yield may obtain.

6. Scope for further studies

Data on (*i*) the phenological aspects of jowar crop such as time of panicle initiation, dates and duration of vegetative and reproductive phases, (*ii*) crop features like number of leaves per plant at flowering time, height of crop and population density, (*iii*) soil moisture status at the time of sowing, (*iv*) soil moisture and rainfall availability in the vegetative phase and (*v*) meteorological parameters, would require to be recorded in sowing date/multi-location trials. When such data becomes available, a more precise understanding of the eco-physiological basis for the variations in the straw and grain yield of jowar would emerge. This in turn would assist better crop yield prediction from weather data and in planning the agronomic strategy for good and bad rainfall years.

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References

Rao, N.G.P., 1971, Sorghum Workshop Recommendations, *Indian Farming*, **21**, 7, 49-50.

Rana, B.S., Balakotaih, K., Tripathi, D.P. and Rao, N.G.P., 1972, Adaptability of Grain Sorghum by Hybrids and Varieties in India in, *Sorghum in Seventies*, Oxford and IBH Pub. Co., 528-535.

Rao., N.G.P., Subba Roa, S. and Vidyasagar Rao, K., 1975, Rainfall Fluctutations and Crop yields, *Curr. Sci.*, **44**, 694-697.

Venkataraman, S., Boothalingam, P.N. and Smt. N.N. Khambete, 1973, Probable Ground Water Recharge in Selected Dry Land Farming Areas, India met. Dep. Prepubl. Sci. Rep. No. 198.