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Identification of Contingent Crops for Delayed Sowing in Dryland Agriculture

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Abstract – **A field experiment was conducted during *kharif* 2018 on "Identification of contingent crops for delayed sowing under changed climate in dryland agriculture" at Dryland Agriculture Project Unit, All India Coordinated Research Project (AICRP) on Dryland Agriculture, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka. The experiment comprised of two factors laid out in Factorial Randomized Complete Block Design (FRCBD) with three replications. Treatments consisted of two factors. *i.e.*, sowing windows and crops. Sowing window consists of August 2nd fortnight, September 1st fortnight and September 2nd fortnight and the crops were foxtail millet, finger millet, field bean, french bean and quiona. Date of sowing decides the availability of weather conditions mainly temperature, light and humidity to the plants which have great influence on expression of growth characteristics in plants. Delayed dates of sowing caused drop in growth parameters which may be due to unfavorable weather conditions to the plants as well as high temperature which might have caused in lower rate of photosynthesis and reduced accumulation of food materials. Among the contingent crops and delayed sowings in *kharif* season under dryland condition, french bean is the most efficient contingent crop suitable for delayed sowings during August 2nd fortnight, September 1st fortnight and September 2nd fortnight for obtaining higher vegetable yield (2394, 1822 and 1150 kg ha^{-1}, respectively) and rain water use efficiency (14.08, 10.98 and 8.16 kg ha-mm^{-1}, respectively). French bean is the best contingent crop suitable to dryland condition to obtain higher finger millet equivalent yield (1789 kg ha^{-1}), net returns (₹ 33191 ha^{-1}) and B C ratio (2.62) compared to field bean, finger millet, foxtail millet and quinoa.**

Keywords – **Delayed Sowing, Contingent Crops, Dryland Agriculture, Rainfed Agriculture, French bean.**

I. INTRODUCTION

Rainfall is the most important but variable climatic parameter in crop planning especially in the regions of dryland agriculture. The dryland agro ecology is characterized as vulnerable for agricultural operations which revolve around moisture availability due to rainfall pattern, amount, intensity and its uses for crop production [1]. The productivity of crops in dryland conditions varies to a great deal from year to year in response to the variability of climate particularly the rainfall [2]. Indisputably, the rainfed farming would continue to occupy an important role in Indian farming for a long time to come [3]. The major source of water for dryland crops is rain, a larger portion of which is received through the South-West monsoon period. The South-West monsoon accounts for nearly 75 to 80 per cent of the natural precipitation received in the country. Therefore, exert a strong influence on *kharif* food grain production and the economy in terms of agricultural output, farmers' income and price stability. The amount of rainfall and its distribution are crucial factors influencing the performance of agriculture. The probability of monsoon rains being erratic is 40 per cent of the time which implies that in 4 out of 10 years there would be an adverse impact on crop production. In drylands, occurrence of drought is quite frequent at any stage of crop growth and length of growing period is short ranges from 75 to

120 days. Vagaries in monsoon rains and breaks of varying duration are most common in dryland areas. Identification of crop is the first step and considered as a base of contingency cropping that leads to development of strategic measure in dryland agriculture to sustain during the monsoon failure or delay of monsoon. Hence, the present experiment was taken up to identify the best contingent crops for delayed sowing under changed climate in dryland agriculture.

II. Material and Methods

A field experiment was conducted during *Kharif* 2018 at Dryland Agriculture Project Unit, GKVK, Bangalore (Karnataka). The experimental site is situated in the Eastern Dry Zone (Zone-5) of Karnataka which is located between 12º 51' N Latitude and 77º 35' E Longitude at an altitude of 930 m above the mean sea level (MSL). The type of soil is red sand loamy in nature. The experiment comprised of two factors laid out in Factorial Randomized Complete Block Design (FRCBD) with three replications. Treatments consisted of two factors. *i.e.*, sowing windows and crops. Sowing window consists of August 2nd fortnight, September 1st fortnight and September 2nd fortnight and crops included were foxtail millet, finger millet, field bean, french bean (vegetable) and quiona. All the recommended agronomic and plant protection measures were adopted. Yield of various contingent crops were recorded from net plot area and then calculated hectare yield. Economics of different treatments were estimated based on prevailing local market price of commodities during crop season 2018-19. The data recorded on various observations on growth, yield and soil parameters were subjected to analysis of variance (ANOVA). The level of significance used in 'F' test was at 5 per cent. The critical difference (CD) values are given in the table at 5 per cent level of significance [4].

III. Results and Discussion

3.1 *Influence of Weather on Growth and Development of Contingent Crops*

The productivity of a crop is often dependent on full exploitation of favourable growth period in an agro-climatic region. Duration of crop in different environment is controlled by its relative photo periodic response, to a certain extent to thermo-periodic response and to a much lesser extent to the stress induced postponement or hastening of growth periods.

A total of 182.00 mm of rainfall was received during the crop growth period of all crops which were sown on August 2nd fortnight, where as it was 166 mm for September 1st fortnight sown crops and 141 mm for September 2nd fortnight sown crops during *kharif* season, 2018. The average maximum temperature of 27 ºC and minimum of 18.8 ºC was recorded for August sown crops, whereas, it was 29.2 ºC and 19.2 °C for September sown crops. The temperature was increased gradually during later sowing of contingent crops at early stages of their growth. The pan evaporation rate of crop period was gradually increased from 3.0 mm day^{-1} to 4.0 mm day^{-1} during crop season because of mean relative humidity percentage was reduced from 94 per cent to 89 per cent during crop period (Table 1). On the other hand, lower levels of rainfall also recorded during crop growth (Table 2). Because of all these climatic effects, moisture availability reduced and leads to more number of dry spells. It resulted in reduction of yield in the late sown crops. The higher rainfall and favourable temperature reflected in better crop growth lead to higher yields of August sown crops.

All the contingent crops sown under different delayed sowings were germinated except quinoa sown during September 2nd fortnight. It might be due to occurrence of high rainfall leads to formation of crust on small size

seeds of quinoa leads to unavailability of oxygen (hypoxia) and sunlight. It results in poor germination of the quinoa crop. It also due to high rainfall on the day of sowing created the water logged conditions in plot due to more clay content of soil. It also leads to hypoxia of quinoa seeds. Emergence is poor if continuous rain prevails immediately after sowing or because of the mortality of young seedlings caused by submergence [5]. And because of high day temperatures of October month and moisture stress leads to death of germinated quinoa seedlings.

Table 1. Weather conditions prevailed during crop growth period of *kharif* 2018-19.

Sl. No.	Month	Rainfall (mm)	Temperature (°C)		Relative humidity (%)	Pan evaporation (mm)	PET (mm)
			Max.	Min.			
1	August	66	27.0	18.8	94	3.0	3.1
2	September	102	29.2	19.2	92	3.8	3.5
3	October	52	28.9	17.8	91	4.2	3.4
4	November	12	28.4	16.9	89	4.0	3.4
5	December	0	27.8	16.3	89	4.0	3.2

Table 2. Distribution of rainfall during crop growth period of *kharif* 2018-19.

Standard meteorological week	Duration	Rainfall (mm)	Standard meteorological week	Duration	Rainfall (mm)
34	20th Aug – 26th Aug	0	44	29th Oct – 04th Nov	0
35	27th Aug – 02nd Sep	16	45	05th Nov – 11th Nov	0
36	03rd Sep – 09th Sep	0	46	12th Nov – 18th Nov	0
37	10th Sep – 16th Sep	25	47	19th Nov – 25th Nov	12
38	17th Sep – 23th Sep	0	48	26th Nov – 02nd Dec	0
39	24th Sep – 30th Sep	77	49	03rd Dec – 09th Dec	0
40	01st Oct – 07th Oct	0	50	10th Dec – 16th Dec	0
41	08th Oct – 14th Oct	0	51	17th Dec – 23rd Dec	0
42	15th Oct – 21st Oct	52	52	24th Dec – 31st Dec	0
43	22nd Oct – 28th Oct	0	01	01st Jan – 07th Jan	0

3.2 *Effect of different delayed dates of Sowing on the Yield of Contingent Crops*

3.2.1 *Seed or Vegetable Yield*

Among the dates of sowing, August 2nd fortnight sowing has produced significantly higher seed / vegetable yield (1033 kg ha^{-1}) and followed by September 1st fortnight sowing (670 kg ha^{-1}) and September 2nd fortnight sowing (413 kg ha^{-1}). The trend of yield reduction of contingent crops was due to the early sown crops have an advantage of favourable soil moisture, temperature and day length which made the crops to express “their full potentiality”. As a result higher grain yield was obtained with early sowing than that of delayed sowing. The yield reduction in delayed sowing was attributed to greater biotic and abiotic stresses *viz*., moisture stress, high temperature and decreased moisture availability and moisture stress that resulted in lesser total dry matter

production and its translocation from vegetative parts to reproductive structures. It was attributed to reduced productive tillers plant^{-1}, number of pods plant^{-1}, panicle weight and pod weight as well as reduced translocation from source to sink with delayed sowing. Similar results have been reported by [6] and [7] in finger millet.

Among the crops, higher vegetable yield (1789 kg ha^{-1}) of french bean was recorded and followed by finger millet and field bean seed yield (659 and 658 kg ha^{-1}, respectively). Lower seed yield produced by quinoa crop (61 kg ha^{-1}). There was no significant difference in seed yield of quinoa under different delayed dates of sowing. However, higher seed yield of quinoa recorded during August 2nd fortnight sowing (115 kg ha^{-1}) and followed by September 1st fortnight sowing (68 kg ha^{-1}). It might be due to unfavorable climatic conditions and poor establishment of quinoa crop in initial stages because of moisture stress [8].

Seed or vegetable yield of all contingent crops was reducing gradually by delaying the sowing date. French bean recorded the highest vegetable yield (2394, 1822 and 1150 kg ha^{-1}, respectively) during August 2nd fortnight, September 1st fortnight and September 2nd fortnight sowings followed by finger millet sown in August 2nd fortnight (1102 kg ha^{-1}). Lower seed yield (67.72 kg ha^{-1}) was produced in quinoa during September 1st fortnight sowing. French bean recorded higher vegetable yields in all delayed sowings when compared to other contingent crops was due to short duration of crop, higher photosynthetic rate, higher biomass production, higher water use efficiency and lower transpiration quotient and also more number of pods plant^{-1}, higher total dry matter production and its accumulation in pods. Similar results have been reported by [9].

3.2.2 *Harvest Index*

Harvest index represents efficient partitioning of assimilates from vegetative parts to reproductive portion. Harvest index of all contingent crops was reducing gradually by delaying the sowing dates. French bean recorded the higher harvest index (0.67, 0.64 and 0.62, respectively) during August 2nd fortnight, September 1st fortnight and September 2nd fortnight sowings followed by field bean sown in August 2nd fortnight (0.45). Lower harvest index (0.26) was recorded in foxtail millet during September 2nd fortnight sowing. French bean crop was grown for vegetable purpose. Due to its high dry matter production and short duration nature, it was harvested three times, so the harvest index was more for french bean. But in foxtail millet and finger millet due to its long duration nature and moisture stress at translocation of food materials from source to sink was greatly affected and recorded less harvest index than other crops.

3.2.3 *Finger Millet Equivalent Yield*

Finger millet equivalent yield represents conversion of contingent crop yields in terms of finger millet yield. It is calculated by yield of crop is converted into equivalent yield of finger millet crop based on the price of the produce. Finger millet equivalent yield was significantly influenced by different delayed sowing of contingent crops. Among the dates of sowing, August 2nd fortnight sowing has produced significantly higher finger millet equivalent yield (1132 kg ha^{-1}) and followed by September 1st fortnight sowing (740 kg ha^{-1}) and September 2nd fortnight sowing (454 kg ha^{-1}).

Among the crops, the french bean recorded maximum finger millet equivalent yield (1789 kg ha^{-1}) followed by field bean and finger millet (987 and 659 kg ha^{-1}, respectively). Minimum finger millet equivalent yield produced by quinoa crop (204 kg ha^{-1}).

Finger millet equivalent yield of all contingent crops was reducing gradually by delaying the sowing date. French bean recorded the maximum finger millet equivalent yield (2394, 1822 and 1150 kg ha^{-1}, respectively) during August 2nd fortnight, September 1st fortnight and September 2nd fortnight sowings followed by field bean sown in August 2nd fortnight (1340 kg ha^{-1}). Lower finger millet equivalent yield (84 kg ha^{-1}) was produced in foxtail millet during September 2nd fortnight sowing.

3.3 *Economics of different Contingent Crops under Delayed Sowing*

Higher gross returns and benefit cost ratio were realized during August 2nd fortnight (₹ 33972 ha^{-1} and 2.18, respectively) followed by September 1st fortnight sowing (₹ 22195 ha^{-1} and 1.42, respectively) and September 2nd fortnight sowing (₹ 13630 ha^{-1} and 0.87, respectively). Similar type of results reported by [10] and [11].

Higher net returns were obtained in August 2nd fortnight (₹ 18363 ha^{-1}) than the September 1st fortnight sowing (₹ 6586 ha^{-1}) and September 2nd fortnight sowing (₹ -1979 ha^{-1}). Negative net returns were recorded during September 2nd fortnight sowing due to lower production of yields of all contingent crops. It was due to moisture and temperature stress during terminal stages of crop growth.

French bean recorded the highest gross and net returns (₹ 71817 and ₹ 51347 ha^{-1}; ₹ 54667 and ₹ 34196 ha^{-1}; ₹ 34500 and ₹ 14030 ha^{-1},respectively) during August 2nd fortnight, September 1st fortnight and September 2nd fortnight sowings followed by field bean sown during August 2nd fortnight (₹ 40208 and ₹ 23718 ha^{-1}, respectively). Lower gross and net returns (₹ 2529 and ₹ -9258 ha^{-1}, respectively) was recorded in foxtail millet during September 1st fortnight sowing.

Foxtail millet recorded the higher negative net returns during September 1st and 2nd fortnight (₹ -5909 and ₹ -9258 ha^{-1}, respectively) due to lower yields than august 2nd fortnight sowing. The yield of foxtail millet is drastically reduced in unfavorable climatic situations. On the other hand, the yield potential of foxtail millet was less among the contingent crops during unfavorable climatic conditions [10].

Quinoa crop was also recorded the negative net returns during August 2nd fortnight and September 1st fortnight sowings (₹ -3525 and ₹ -8295 ha^{-1}, respectively). This was due to lower yields of quinoa because of poor establishment of crop in initial stages due to moisture stress and unfavorable climatic conditions.

Table 3: Effect of different delayed dates of sowing onseed or vegetable yield (kg ha^{-1}), harvest index, finger millet equivalent yield (kg ha^{-1}) and economics of contingent crops.

Treatments	Seed / vegetable yield (kg ha^{-1})	Harvest Index	Finger millet equivalent yield (kg ha^{-1})	Gross returns (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net returns (₹ ha^{-1})	B: C Ratio
Sowing window (S)							
S_1	1033	0.49	1132	33972	15609	18363	2.18
S_2	670	0.47	740	22195	15609	6586	1.42
S_3	413	0.32	454	13630	15609	-1979	0.87
SEm±	**154.1**	**0.03**	**163.3**	**NA**	**NA**	**NA**	**NA**
CD (5%)	**268.3**	**0.05**	**283.9**	**NA**	**NA**	**NA**	**NA**
Crops (C)							
C_1	361	0.28	240	7210	11787	-4577	0.61

Treatments	Seed / vegetable yield (kg ha^{-1})	Harvest Index	Finger millet equivalent yield (kg ha^{-1})	Gross returns (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net returns (₹ ha^{-1})	B: C Ratio
C_2	659	0.33	659	19757	14233	5524	1.39
C_3	658	0.44	987	29597	16490	13017	1.79
C_4	1789	0.64	1789	53661	20470	33191	2.62
C_5	61	0.42	204	6104	15067	-8963	0.41
S x C							
S_1C_1	661	0.33	441	13222	11787	1435	1.12
S_2C_1	294	0.27	196	5878	11787	-5909	0.50
S_3C_1	126	0.26	84	2529	11787	-9258	0.21
S_1C_2	1102	0.35	1102	33071	14233	18838	2.32
S_2C_2	581	0.33	581	17421	14233	3188	1.22
S_3C_2	293	0.30	293	8778	14233	-5456	0.62
S_1C_3	894	0.45	1340	40208	16490	23718	2.44
S_2C_3	583	0.44	875	26238	16490	9748	1.59
S_3C_3	496	0.43	745	22345	16490	5855	1.36
S_1C_4	2394	0.67	2394	71817	20470	51347	3.51
S_2C_4	1822	0.64	1822	54667	20470	34197	2.67
S_3C_4	1150	0.62	1150	34500	20470	14030	1.69
S_1C_5	115	0.44	385	11542	15067	-3525	0.77
S_2C_5	68	0.40	226	6772	15067	-8295	0.45
S_3C_5	0	0.00	0	0	0	0	0
SEm±	**68.05**	**0.01**	**73.0**	**NA**	**NA**	**NA**	**NA**
CD (5%)	**199.5**	**0.03**	**211.6**	**NA**	**NA**	**NA**	**NA**

Factor- A : Sowing window (S)		Factor- B : Crops (C)	
S_1	: August 2nd fortnight (28.08.2018)	C_1	: Foxtail millet
S_2	: September 1st fortnight (14.09.2018)	C_2	: Finger millet
S_3	: September 2nd fortnight (24.09.2018)	C_3	: Field bean
		C_4	: French bean
		C_5	: Quinoa

IV. CONCLUSION

Among the contingent crops, french bean is the most efficient contingent crop suitable for delayed sowings during August 2nd fortnight, September 1st fortnight and September 2nd fortnight for obtaining higher vegetable yield (2394, 1822 and 1150 kg ha^{-1}, respectively) and rain water use efficiency (14.08, 10.98 and 8.16 kg ha-mm^{-1}, respectively). French bean has obtained higher finger millet equivalent yield (1789 kg ha^{-1}), net returns (₹ 33191 ha^{-1}) and BC ratio (2.62) compared to field bean, finger millet, foxtail millet and quinoa.

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