Sustainability of different cropping systems under varying sowing dates in Marathwada region

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(Received: November, 2011; Revised: December, 2012; Accepted: February, 2013)

ABSTRACT

The field experiments were carried out at Instructional Farm, AICRP on Dry land Agriculture, Marathwada Agricultural University, Parbhani during the rainy season of 2001-2005 on eight different cropping systems consisting of important food, pulse and oilseed crops of Marathwada region under varied weather conditions. The results revealed that intercropping of sorghum (CSH-9)+ pigeonpea, pear millet + pigeonpea and castor + soybean sown in 26 meteorological week (MW) produced the highest grain yield and average productivity of the system during all the years of experimentation as compared to rest of the cropping systems. Similarly, castor + soybean produced the highest sorghum grain equivalent which was at par with soybean + pigeonpea, *Arborium* cotton + soybean and cotton (NHH-44) + soybean. The sowing of all the crops and cropping systems on 26 MW recorded significantly highest sustainable yield index (0.52) as compared to sowing of all cropping systems on delayed sowing dates.

Keywords: Cropping systems, Grain yield, Oilseeds, Sustainable yield index

For feeding the burgeoning population and to meet the protein requirements there is an urgent need to increase production and productivity of grain legumes and oilseeds. As the scope to increase area under sole cropping is limited, the only alternative left is to increase the area through cropping systems intercropping and double cropping. The intercropping is a potentially beneficial system having substantial yield advantage over sole cropping with reduction in risk. Whereas, with the introduction of short duration hybrids and high yielding varieties, scope of double cropping is increased. Sowing time is the most important non monetary input affecting the crop yield. Even in photo and thermo insensitive crops, it is a critical input for higher yield. Delayed sowing invariably reduces the yields, whereas sowing early in the season may also not be advantageous as the crops does not receive favourable environment at various phenological stages. Therefore the present investigation was planned to study effect of different cropping systems under varied sowing dates.

MATERIALS AND METHODS

The field research was carried out during the rainy season of 2001 to 2005 at Instructional Farm, AICRP on Dryland Agriculture, Marathwada Agricultural University, Parbhani. Eight different promising cropping systems of important crops of Marathwada region were tested in varied weather condition under rainfed agriculture.

The experiment was laid out in split plot design with three replications. The treatment consisted of four sowing dates as a main plot D_1-26 meteorological week (MW) (29 June, 2000), D_2-28MW (14 July, 2000), D_3-30MW (28 July, 2000) and D_4-32MW (10 August, 2000) and eight cropping systems as a sub plot treatment having 32 treatment combinations. Eight cropping system comprises C_1-sorghum (CSH-9) + pigeonpea (BSMR-853) (4:2), C_2-HYV of sorghum (PVK-801) + pigeonpea (BSMR-853) (4:2), C_3-cotton (NHH-44) + soybean (MAUS-47) (1:1), C_4- improved *Arborium* cotton (TURAB) + soybean (MAUS-47) (1:1), C_5-pearlmillet (AIMP-92-901) + pigeonpea (BSMR-853) (3:3), C_6-soybean (MAUS-47) + pigeonpea (BSMR-853) (4:2), C_7-castor (DCS-9) +soybean (MAUS-47) (1:1) and C_8 - greengram (BM-4) + winter sorghum (M-35-1). The recommended dose of fertilizer was given as per recommendations for individual crops. All the recommended inter cultivation and plant protection measures were followed:

Sustainable Yield Index (SYI)

The sustainable yield index (SYI) is defined as:

$$SYI = \frac{\overline{Y} - \sigma}{Y_{max}}$$

Where y is the estimated average yield of a practice over years, σ is its estimated standard deviation and Y_{max} is the observed maximum yield in the experiment. In calculating SYI the negative values of $(y - \sigma)$ should be taken as zero since yield is always a positive quantity. With this premise, the index taken values between zero and unity. In this index σ quantify the risk associated with the average performance y of a treatment. When $\sigma = 0$ and $y = y_{max}$, SYI = 1. This is an

ideal treatment. This treatment gives consistently maximum yield in all the years. But invariably in biological system σ is always greater than zero since there exits variations in the yield over years because of the variation in the distribution of rainfall and other factors of the standard deviation is very high then the value of the index will be less, there by indicating the unstable nature of the practice. In case when there is no significant difference in the variances associated with each treatment over years, then the index is proportional to the mean values of the treatments. But in general, under dryland conditions, heterogeneity exists in treatment variances since the treatments interact with the environment. For generalizing the interpretations of the values of the index, there should be sufficient number of years representing the range of variations commonly observed at a given locations. Further, characterization of the environment is important for interpreting index, particularly when comparing the values of the index at different locations. Therefore, data from the experiments conducted for at least two years and in most of the cases more than two years have been considered for this study.

In general, the treatment having high mean and low standard deviation is preferred. But the possible types of situations to come across are: (I) High mean and low standard deviation; (ii) High mean and high standard deviation; (iii) Low mean and low standard deviation and (iv) Low mean and high standard deviation

The last and the first situations are duly distinguished by the index SYI. The first situation leads to high value and the fourth situation leads to low value of the index. In some cases the index may fail to distinguish between the second and the third situations. In the second group, the treatments are responsive but unstable, whereas in the third group they are not responsive but stable. When the index has similar values for the treatments failing in the second and third group, the selection of the treatments depends on certain constraints on Y and σ. The risk aversive farmer may select the treatment with greater Y. The index does not say anything about the absolute value of the average yield. Hence the index may be supplemented with average yield. However, SYI denotes the minimum guaranteed yield as a per cent to the maximum observed yield with high probability. Under dryland conditions, maximization of minimum sustainable yield over years is important as mentioned earlier. The index SYI will help in assessing the treatments in the light of sustainable yield.

The mean and the standard deviation are estimated by

$$\textbf{Estimated mean} = \bar{Y} = \frac{\sum y_i}{N}$$

$$\textbf{Estimated standard deviation} = \frac{\sqrt{\sum Y_i^2 - (\sum Y_i)2/n}}{(n-1)}$$

Where,
Y_i is the yield in the i^{th} year and
n = number of years

RESULTS AND DISCUSSION

Grain yield: Intercropping of sorghum (CSH-9) + pigeonpea (BSMR-853) (C_1), pearl millet (AIMP-92-901) + pigeonpea (BSMR-853) (C_5) and castor (DCS-9) + soybean (MAUS-47) sown on 26 MW produced the highest grain yield of the cropping systems in all the years of experimentation as compared to rest. It was followed by *Arborium* cotton (TURAB) + soybean (MAUS-47) (D_1C_4) which was comparable with the treatment combination of soybean (MAUS- 47) + pigeonpea (BSMR-853) (D_1C_6). Similarly, under late sown condition (15 days after normal sowing), soybean (MAUS-47) + pigeonpea (BSMR-853) recorded highest grain yield followed by pearl millet (AIMP-92-901) + pigeonpea (BSMR-853) cropping system.

Productivity of the system: Normal sowing on 26 MW recorded the highest mean productivity during all the years of experimentation and in pooled data, respectively. The lowest mean productivity was observed when sowing of all the cropping systems was taken up in D_4 (32 MW).

Amongst the different cropping systems under study, C_5- pearl millet (AIMP-92-901) + pigeonpea (BSMR-853) and castor (DCS-9) + soybean (MAUS-47) (C_7) recorded significantly higher productivity of 2154 and 1954 kg/ha in pooled data and was significantly higher than the productivity obtained in rest of the cropping systems. The lowest productivity was recorded by sorghum (CSH-9) + pigeonpea (BSMR-853) (C_1) followed by sorghum (PVK-801) + pigeonpea (BSMR-853) (C_2). Decrease in yield with delayed sowing was reported in pigeonpea (Saxena *et al.*, 1977); sorghum; castor (Deokar *et al.*, 1977); pearl millet (Kaushik and Gautam, 1984) and *deshi* cotton (Sharma *et al.*, 1989).

Sorghum grain equivalent yield: The pooled analysis revealed that castor (DCS-9) + soybean (MAUS-47) (C_7) produced the highest sorghum grain equivalent which was at par with soybean (MAUS-47) + pigeonpea (BSMR-853), *Arborium* cotton (TURAB)+ soybean (MAUS-47) and cotton (NHH-44) + soybean (MAUS-47) and they were found significantly superior over rest of the cropping systems. The lowest sorghum grain equivalent yield was recorded by green gram (BM-4)+ winter sorghum (M-35-1) (C_8) and sorghum (CSH-9) + pigeonpea (BSMR-853) (C_1).

Table 1 Grain yield of various cropping systems under different sowing dates (Average of 5 years from 2000-2005)

Treatment	Mean grain yield (kg/ha)							
	D_1 (29 June)		D_2 (14 July)		D_3 (28 July)		D_4 (10 August)	
	M	I	M	I	M	I	M	I
Cropping system								
C_1 Sorghum (CSH-9) + Pigeonpea (BSMR853) (4:2)	2104	874	--	894	--	756	--	536
C_2 HYV.Sorghum (PVK-801)+Pigeonpea (BSMR-853) (4:2)	1732	1034	--	912	--	735	--	571
C_3 Cotton(NHH-44)+Soybean (MAUS-47) (1:1)	1078	1462	791	802	561	484	448	433
C_4 *Arborium* Cotton (TURAB)+ Soybean (MAUS-47) (1:1)	918	1655	613	990	446	531	417	435
C_5 Pearlmillet (AIMP-92-901) +Pigeonpea (BSMR-853) (3:3)	1861	1013	1721	818	1379	675	1047	520
C_6 Soybean (MAUS-47) + Pigeonpea (BSMR-853) (4:2)	1535	1006	826	896	554	753	400	517
C_7 Castor (DCS-9)+ Soybean (MAUS-47) (1:1)	1757	1104	1695	741	1348	476	1108	357
C_8 Greengram (BM-4)+ Winter Sorghum (M-35-1)	667	1434	301	1421	110	1198	73	1154
Mean	1457	1198	991	934	733	701	582	565

Note: The sowing of all the treatments were undertaken as D_1 (29 June), D_2 (14 July), D_3 (28 July), D_4 (10 August) and sowing dates were kept constants from 2001 to 2005 for every year.

Table 2 Productivity of different cropping systems as influenced by various sowing dates

	Productivity (kg/ha)						Sorghum grain equivalent yield (pooled)	Sustainable yield index
	2001	2002	2003	2004	2005	Pooled mean		
Sowing date								
D_1-26 MW	2211	2704	2128	2689	2845	2515	6058	0.523
D_2-28 MW	1508	1150	1648	1994	1820	1704	4702	0.376
D_3-30 MW	906	969	856	1633	1557	1184	3208	0.174
D_4-32 MW	752	822	421	1069	1320	878	2257	0.08
CD (P=0.05)	104	69	62	125	182	200	1130	0..72
Cropping system								
C_1 Sorghum(CSH-9)+Pigeonpea (BSMR-853) (4:2)	956	1065	1170	1373	1365	1158	3308	0.185
C_2 HYV.Sorghum (PVK-801) +Pigeonpea (BSMR-853) (4:2)	982	1100	1159	1278	1634	1231	3393	0.178
C_3 Cotton(NHH-44)+Soybean (MAUS-47) (1:1)	1062	1107	811	1733	2045	1351	4501	0..68
C_4 *Arborium* Cotton (TURAB) + Soybean (MAUS-47) (1:1)	1235	1515	1043	2003	1427	1444	4662	0.205
C_5 Pearlmillet (AIMP-92-901)+Pigeonpea (BSMR-853) (3:3)	1765	1985	1788	2510	2723	2154	4074	0.458
C_6 Soybean (MAUS-47) + Pigeonpea (BSMR-853) (4:2)	1243	1450	1133	1871	1857	1510	4642	0.211
C_7 Castor (DCS-9) + Soybean (MAUS-47) (1:1)	1539	2078	1640	2282	2231	1954	4760	0.562
C_8 Greengram (BM-4)+Winter Sorghum (M-35-1)	1573	1567	1361	1319	1401	1524	3112	0.439
CD (P=0.05)	116	84	116	160	291	164	CD at 5%	116
Interaction (DxC)								
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	0.195

Note: The sowing of all the treatments were undertaken as D_1 (29 June), D_2 (14 July), D_3 (28 July), D_4 (10 August) and sowing dates were kept constants from 2001 to 2005 for every year.

Sustainable yield index: Sowing of all the crops and cropping systems on 26 MW (D_1) recorded significantly highest values of sustainable yield index (0.52) as compared to delayed sowing. This clearly indicates significance and suitability of this sowing date (26 MW) in maintaining the sustainability of cropping systems. It was followed by D_2 i.e., 28 MW (0.376) which was significantly superior over rest of the sowing dates. However, sowing at 32 MW had recorded lowest values (0.08) indicating non suitability of this sowing date for most of the cropping systems under study.

Among all the cropping system under study, castor (DCS-9) + soybean (MAUS-47) (D_1C_7) recorded highest values for sustainable yield index thereby clearly indicating its high degree of stability and sustainability under all the dates of sowing under varied environmental conditions. It was followed by pearl millet (AIMP-92-901) + pigeonpea (BSMR-853) (D_1C_5) which was comparable with green gram (BM-4) + winter sorghum (M-35-1) (D_1C_8) and both of them recorded significantly higher sustainable yield index as compared to rest of the crops and cropping systems. The cropping systems cotton (NHH-44) + soybean(MAUS-47), sorghum (CSH-9) + pigeonpea (BSMR-853) and HYV sorghum (PVK-801) + pigeonpea (BSMR-853) recorded lowest values for sustainable yield index thereby indicating their unstability and unsuitability under varied

environmental conditions over a period of time. Further on the basis of two way table, it can be stated that pearl millet (AIMP-92-901) + pigeonpea (BSMR-853) sown on 26 MW and castor (DCS-9) + soybean (MAUS-47) sown on 28 MW and 26 MW recorded highest degree of sustainability as compared to rest of the treatment combinations. Similarly, Mulik *et al.* (1996) reported that pearl millet + pigeon pea integrated cropping system was more sustainable. Similarly, stable productivity under varied weather conditions in intercropping of pigeon pea with soybean and sorghum was observed (Anonymous, 1999).

Table 3 Interaction effect of cropping system and sowing dates as sustainable yield index

Treatment	Sustainable yield index				
Cropping System	D_1 (29 June)	D_2 (14 July)	D_3 (28 July)	D_4 (10 August)	Mean
C_1 Sorghum(CSH-9)+Pigeonpea (BSMR-853) (4:2)	0.50	0.17	0.05	0.01	0.18
C_2 HYV.Sorghum (PVK-801)+Pigeonpea (BSMR-853) (4:2)	0.53	0.13	0.01	0.02	0.17
C_3 Cotton(NHH-44)+Soybean (MAUS-47) (1:1)	0.44	0.33	0.07	-0.42	0.06
C_4 *Arborium* Cotton (TURAB)+ Soybean (MAUS-47) (1:1)	0.47	0.35	0.02	-0.02	0.20
C_5 Pearlmillet (AIMP-92-901)+Pigeonpea (BSMR-853) (3:3)	0.68	0.45	0.37	0.23	0.45
C_6 Soybean (MAUS-47)+Pigeonpea (BSMR-853) (4:2)	0.46	0.47	0.06	-0.14*	0.21
C_7 Castor (DCS-9)+ Soybean (MAUS-47) (1:1)	0.61	0.64	0.50	0.48	0.56
C_8 Greengram (BM-4)+Winter Sorghum (M-35-1)	0.48	0.35	0.43	0.48	0.43
Mean	0.52	0.37	0.17	0.08	0.28

SEm± = 0.071; CD (P=0.05) = 0.195

Note: The sowing of all the treatments were undertaken as D_3 (29 June), D_2 (14 July), D_3 (28 July), D_4 (10 August) and sowing dates were kept constants from 2001 to 2005 for every year.

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