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Growth, productivity and economics of coral-432 (Indian mustard hybrid) under different cropping systems

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Abstract

An experiment was conducted on the performance of Indian mustard hybrid Coral-432 under semi-arid conditions during the 2010-11 and 2011-12 *Rabi* season at ICAR-Directorate of Rapeseed-Mustard Research (DRMR), Research Farm, Bharatpur, Rajasthan, India. Of the seven cropping systems (groundnut-mustard, cotton- mustard, soybean-mustard, pearl millet-mustard, sesame-mustard, cluster bean-mustard, and fallow-mustard) tested, maximum growth rates at 30-60 days after sowing (DAS), 60-90 DAS, and 90 DAS to harvest, respectively, were obtained under sesame-mustard, fallow-mustard, and pearl millet-mustard cropping systems. Among the yield attributes, the maximum number of primary branches, numbers of siliqua and 1000-seed weight were obtained under sesame-mustard, cluster bean-mustard, and fallow–mustard, respectively. Number of secondary branches per plant, number of seeds per siliquae and siliquae length were maximum under the pearl milletmustard cropping system. Maximum seed yield per hectare was obtained under the sesame-mustard cropping system.

Key words: Crop growth rate, cropping system, economics, mustard hybrid, productivity

Introduction

Indian mustard is an important oilseed crop of India, cultivated in over 6.5 m ha with an annual gross production and average yield of 7.8 MT and 1208 kg/ha respectively (Anonymous, 2013). The mustard growing areas in India differ significantly in the agro-climatic conditions. In irrigated regions, mustard is grown with different crops in spatial (sequence cropping) and temporal (intercropping, mixed cropping etc.) adjustments. Due to adoption of improved mustard varieties, its production in the country has increased steadily during the last five years. But considering the demand supply gap of edible oil in India, there is still a huge growth potential in this segment. Mustard is important crop in rain-fed areas and in areas of low rain fall where farmers usually grow single crop of mustard by keeping their fields fallow during the *Kharif* rainy season. The development of hybrids in Indian mustard is new breeding strategy and the yield advantage of hybrids over the non-hybrid varieties may be harnessed by following the completely different package of practice in cropping system mode.

The hybrid variety performs differently in mono-cropping, and than in mixed cropping system, possibly due to the difference in interaction of plant type, competition with weeds, root exudates, and rhizosphere microflora. The nature of interaction of the hybrids with other crops depends on many factors includes morpho-physiological traits, and on the root, shoots exudates. Little work has been done on the performance of mustard hybrid under different cropping systems. Although, hybrids have yield advantage over the existing non-hybrid varieties, the effect of their vigorous growth and development on other crops in intercropping, and in crop sequence, needs to be studied in detail. Coral 432 is a promising mustard hybrid, but its suitability under various cropping systems under semi arid conditions has not been studied in detail. Keeping this in view, a study was undertaken at the ICAR-DRMR research farm during 2010-11 and 2011-12, to determine performance of mustard hybrid Coral

-432, under various cropping systems in semi-arid conditions.

Materials and Methods

The experiment was conducted during the 2010-2011 and 2011-12 *Rabi* (winter) seasons. The details of procedures followed, criteria used for treatment evaluation, and methods adopted during entire course of investigation are described below.

Experimental Site

Field experiments were conducted at the research farm of ICAR-DRMR, Bharatpur, Rajasthan, India, situated at 27.15^0N Latitude, 77.30^0E Longitude at an altitude of 178.37 m above mean sea level. During the two cropping seasons, the relative humidity at 7 AM varied from 66.6 to 98.9 per cent; total rainfall received during the cropping seasons was 392.9 mm.

Soil characteristics

Analysis of a composite soil sample to a depth of 0-30 cm collected from the experimental field prior to sowing revealed that the initial organic carbon content, available N, and available P, and available K were 0.11 %, 105.0 kg/ha, 12.2 kg/h, and 193.7 kg/ha, respectively.

Crop characteristics

Indian mustard (*Brassica juncea*) hybrid var. Coral-432 was released in 2009-2010 for timely sown irrigated conditions of Uttar Pradesh, Haryana, India, and semi-arid regions of Rajasthan. This hybrid matures in 130-145 days, and has a potential yield of 2.2 t/ha with an average per cent oil content 39.4.

Design and layout of field experiment

The study was conducted in a randomized block design with four replications during both 2010-11 and 2011-12 seasons at the ICAR-DRMR, Bharatpur, Rajasthan, India. The seven treatments including fallow-mustard were groundnut-mustard, cotton-mustard, soybean-mustard, pearl millet-mustard, sesame-mustard, and cluster bean-mustard.

Field operations

The experiment was planted on October 30, in 2010-11, and on October 20, in 2011-12. Sowing was performed with the help of a small plough, with row to row spacing of 30 cm. The thinning operation was done two weeks after sowing to maintain inter-row spacing of 15 cm. An uniform basal application of phosphorous @ 40 kg P_2O_5/ha as super phosphate, sulphur @ 40 kg/ha, boron @ 1 kg/ha was made along with a full dose of 25 kg/ha zinc sulphate and half dose of nitrogen (40 kg/ ha) through urea; remaining dose of nitrogen (40 kg/ha) was top dressed after first irrigation. Two irrigations were given 45 and 82 days after sowing. One hand weeding was done manually at the time of thinning. Plants were harvested manually with the help of a sickle when 75% of the siliquae turned yellow and seeds attained their natural colour. Threshing was performed manually after drying the plants in the sun.

Data Collection and statistical analysis

Observations on all important growth characters, yield attributes, and yield (seed, biological) were recorded and analyzed statistically. Growth characters, and yield attributes including plant height, number of branches per plant, dry matter accumulation per plant (g), and days of various growth stages were observed. The average height in cm of 5 randomly selected plants was recorded from base to tip of the plant in each plot at various growth stages including 30, 60, 90 days after sowing, and at harvest. Similarly, average numbers of branches primary and secondary branches of these plants were recorded. Dry matter accumulation was recorded from 5 plant samples of each plot were uprooted randomly from the marked row (second and third row from east) at various growth stages. The different plant parts were separated and subjected to oven drying at 65^0C temperature till the constant weight was obtained. The dry weight of different plant parts and whole plant has been reported in gram per plant basis. Randomly selected 5 plants were taken for yield attributes, primary and secondary branches, number of siliquae, number of seeds per siliquae, length of siliquae of 20 randomly selected siliquae from main shoot, primary, and secondary branches were measured and average reported as length of siliquae in cm. While reporting the average 1000-seed weight, the weighted mean was calculated on the basis of 1000-seed weight and seed

weight on different branches. The net plot area was harvested, air dried and produce was threshed and cleaned. The final weight was recorded in kg per plot and converted into kg per hectare.

Harvest index

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Harvest index (HI) is the economic yield expressed as percentage of biological yield and calculated as formula given by Donald (1962).

The B:C ratio was estimated from the data on net returns and cost of cultivation (B : C ratio = Net returns/cost of cultivation).

All the experimental data for various growth, yield and yield attributing characters, and economics were statistically analyzed by the method of analysis of variance (ANOVA) as described by Panse and Sukhatme (1995). The significance of treatment effects were computed with the help of 'F' (variance ratio) and to judge the significance of difference between means of two treatments, critical differences (CD) were worked out as described by Cochran and Cox (1963). The economics aspect includes cost of cultivation of Coral-432, gross and net return, and cost -benefit ratio were estimated. The mean of all observations under different cropping systems along with mean standard error (SE) and Critical Difference (CD) values are presented in different tables.

Results and Discussion

Crop growth rate

For both cropping seasons, maximum crop growth rate during 30-60 DAS was recorded under sesame-mustard cropping system statistically followed very closely by CB-mustard, fallow-mustard, groundnut-mustard and soybean-mustard. Cotton-mustard cropping system produced minimum growth rate. During 60-90 DAS, the highest crop growth rate was observed under fallow–mustard, closely followed by sesame–mustard cropping system. Minimum growth rate was recorded under cotton-mustard cropping system in all three growth stages. During 90 days to harvest, maximum crop growth rate was observed under PM-mustard cropping system, closely followed by groundnut-mustard, soybean-mustard and sesame–mustard cropping systems (Table 1). The preceding crops exert effect on succeeding crops in the form of annidation, competition and allelopathy. The positive effect of released root exudates, and pattern of nutrient and water uptake decide the performance of mustard hybrid under various cropping system. In the mixed cropping system. In the mixed cropping system, the various crops exert direct and indirect effect on the companion crop and crops in sequence. The natures of interaction among the crops decide the performance of each other in terms of growth characteristics. This was in conformity with the results of Kirkegaard, 1994, Mandal *et al.*, 2010, and Saha *et al.*, 2010.

Table 1. Effect of various cropping systems on crop growth rate at 30-60, 60-90 and 90 days after sowing to harvest of mustard hybrid coral 432

Treatments	30-60 DAS		60-90 DAS		90 DAS to harvest	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Fallow-mustard	0.57	0.52	1.26	1.24	1.09	1.10
Soybean-mustard	0.47	0.46	0.80	0.89	1.19	1.15
Groundnut-mustard	0.50	0.48	0.80	0.78	1.34	1.30
Cotton-mustard	0.30	0.28	0.79	0.75	0.81	0.95
PM-mustard	0.40	0.37	1.09	1.01	1.52	1.40
Sesame-mustard	0.60	0.58	1.16	1.01	1.16	1.15
CB-mustard	0.58	0.62	1.01	1.25	1.02	1.02
SE (M)	0.05	0.04	0.18	0.15	0.25	0.24
CD at 5%	0.16	0.15	0.35	0.36	0.74	0.72

Yield attributes

In both cropping season, maximum number of siliquae was observed under cluster bean-mustard cropping systems; number of silique per main shoot in cropping system sesame-mustard Whereas, number of siliquae were found maximum under cluster bean-mustard, soybean-mustard and pearl millet-mustard were significantly higher than under fallow-mustard and cotton- mustard (Table 2). Secondary branches, number of seeds per siliqua, and siliqua length were maximum under pearl millet cropping system (Table 2). Maximum 1000 seed weight of Coral-432 was recorded under fallow-mustard which was significantly higher than in cotton-mustard cropping system. Although 1000 seed weight in other cropping systems were lower than in fallow mustard cropping system , but the difference was statistically non significant (Table 2). Since oil and protein accumulates during maturity at the expanse of carbohydrates, and sugar particularly sucrose, their products are the major processors in the formation of oil, and are thus consumed in the biosynthesis of lipids. Similar results have also been reported by Singh, and Singh, 1969, and Acharya and Swain, 2004.

Seed, Biological and oil yield

Overall effect of various cropping system on seed yield of mustard hybrid Coral-432 was significant in 2010-11 and 2011-12, the maximum seed yield were recorded under sesame-mustard and cluster bean-mustard cropping systems respectively. Seed yield of mustard hybrid is mainly determined by the number of primary branches, 1000 seed weight, seeds per siliqua and total number of siliqua per plant. Higher the number of these yield attributing characters better would be the seed productivity. The coefficient of determination (r^2) is determined from observed data on yield attributes and seed yield though MS excel by comparing estimated and actual y-values. In regression analysis, Excel calculates for each point the squared difference between the y-value estimated for that point and its actual y-value. It ranges 0 to 1. Seed yield with yield attributing characters showed >0.5 r^2 value, revealed the reasons for better yield performance in different cropping systems (Fig 1). At the other extreme,

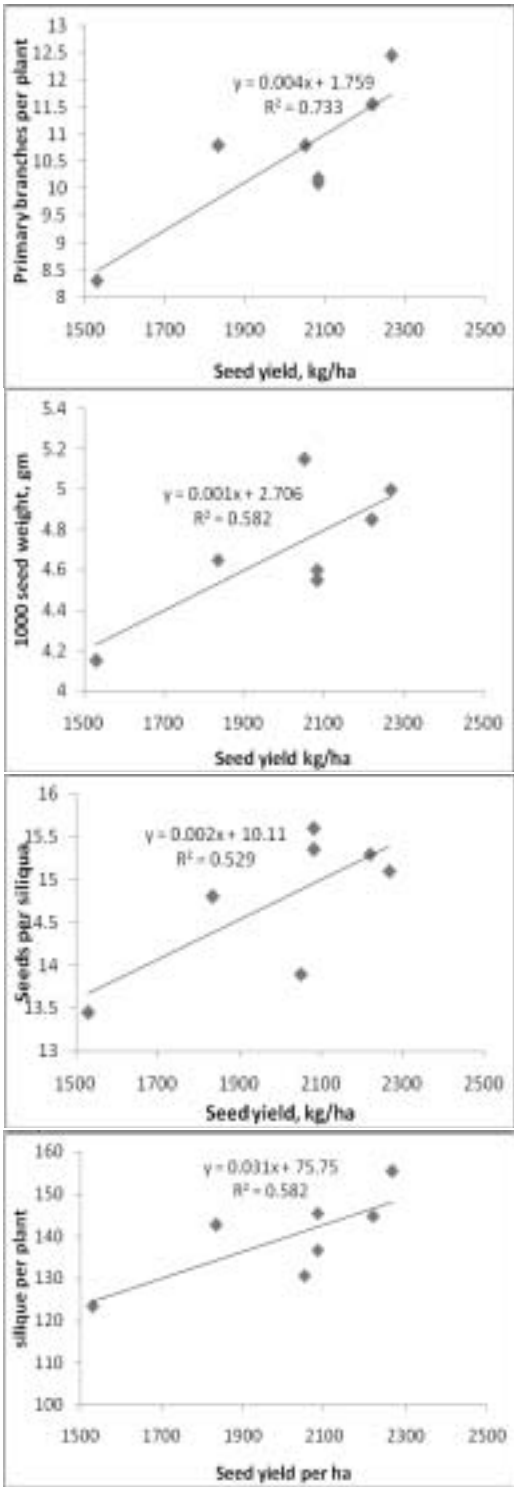

Fig1. Dependence of seed yield on yield attributes of Coral 432 under different cropping system (pooled data of 2 years). Dipcted response equation with seed yield and yield attributing charecters and R2 is the determination coeffecient.

Table 2. Effect of various cropping systems on yield attributes of mustard hybrid, Coral 432

SNo.	Treatments	Primary branches		Secondary branches		Number of siliquae/plant		Number of seeds per siliqua		Siliqua length		1000-seed weight, gm	
		2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
1	Fallow-mustard	11.1	10.5	15.8	13.7	124.5	136.9	13.3	14.5	3.40	3.37	5.1	5.2
2	Soybean-mustard	11.3	10.3	15.6	13.6	143.9	141.5	14.1	15.5	3.57	3.53	4.7	4.6
3	Groundnut-mustard	10.8	9.4	18.0	16.0	140.2	133.3	14.8	15.9	3.50	3.47	4.6	4.6
4	Cotton-mustard	8.4	8.2	18.4	16.4	124.6	122.2	12.9	14.0	3.23	3.30	4.1	4.2
5	Pearl-millet-mustard	10.9	9.5	18.8	16.8	143.9	147.0	15.2	16.0	3.63	3.60	4.5	4.6
6	Sesame-mustard	12.5	10.6	15.3	13.3	148.8	140.7	15.1	15.5	3.47	3.43	4.9	4.8
7	Cluster bean-mustard	11.4	13.5	17.3	15.3	151.2	159.6	14.4	15.8	3.60	3.57	4.9	5.1
	SE (M)	1.3	1.78			8.5	7.6	1.2	1.1	0.15	0.13	0.25	0.24
	CD at 5%	2.3	3.2	NS	NS	18.9	17.8	13.3	14.5	NS	NS	0.75	NS

Table 3. Effect of various cropping systems seed, biological yield and harvest index of mustard hybrid coral 432 during 2010-11

Treatments	Seed yield (kg/ha)		Biological Yield (kg/ha)		Oil yield (kg/ha)		Harvest Index	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Fallow-mustard	2211.5	1891.0	11185.9	8782.1	905.3	774.2	0.20	0.22
Soybean-mustard	1907.1	1762.8	8814.1	7964.7	767.3	709.3	0.22	0.22
Groundnut-mustard	2339.7	1826.9	9487.2	8397.4	940.0	733.7	0.25	0.22
Cotton-mustard	1634.6	1426.3	9647.4	8429.5	661.6	577.4	0.17	0.17
Pearl-millet-mustard	2467.9	1698.7	10705.1	8910.3	1005.2	691.6	0.23	0.19
Sesame-mustard	2596.2	1842.9	9471.2	8895.8	1054.5	748.5	0.27	0.21
Cluster bean-mustard	2323.7	2211.5	9791.7	9535.3	948.2	891.8	0.24	0.23
SE (M)	156.3	162.7	634.5	294.0	63.6	66.3	0.02	0.01
CD at 5%	464.4	383.0	1885.2	873.4	189.0	197.0	0.06	0.02

if the coefficient of determination is 0, the regression equation is not helpful in predicting a y-value. Minimum seed yield of coral-432 was recorded under cotton-mustard cropping system during both years of experimentation (Table 3). The increase in yield was positive among all cropping systems except cotton mustard and soybean-mustard systems compared to fallow-mustard. Maximum increase in seed yield was recorded under sesame-mustard during 2010-11, and under cluster bean-mustard cropping system during 2011-12 over fallow-mustard (Table 3). Different cropping systems had significant effect on biological yield of mustard hybrid coral-432 (Table 3). Maximum biological yield was recorded under fallow-mustard and cluster bean –mustard cropping system during 2010-11 and 2011-12, respectively (Table 3). In both the years, minimum biological yield was observed under soybean-mustard cropping system. Harvest index of coral-432 was significantly influenced by various cropping systems and maximum harvest index was observed under seseme-mustrd, closely followed by cluster bean -mustard cropping system during 2010-11 during the 2011-12, maximum harvest index was recorded under cluster bean–mustard cropping system. The harvest index ranged from 0.17 to 0.27 under various cropping systems (Table 3). The oil content determined by nondestructive FTNIR method and ranged from 39-41 %. Sesame-mustard produced maximum oil yield, while in 2011-12 CB-mustard cropping system yielded maximum oil yild. The reason for statistically significant difference in oil yield was the vast difference on seed yield of coral-432 during both the year. Similar results have also been reported by Singh and Sinsinwar (2003), Santonoceto *et al*., 2002 and Acharya and Swain, 2004).

Economics

Since all components of inputs including field preparations, seed, fertilizers, labour charges, ploughing, weeding, irrigation, plant protection measures, harvesting and thrashing were similar in all the treatments, no variation in cost of production per hectare was observed. Gross return under various cropping systems was estimated by taking into consideration of mustard seed and biological yield. The prevailing market rate of mustard seed was used for calculation of gross return. Maximum gross return was recorded under pearl-millet-mustard, closely followed by sesame-mustard, which were statistically at par with gross return from coral-432 in cluster bean-mustard, groundnut-mustard and fallow-mustard during 2010-11 and during 2011-12, maximum net return was recorded under cluster bean-mustard cropping system. Minimum gross return was observed under cotton–mustard cropping system (table 4).

Maximum net return (Rs 55209) was found under the cropping system of CB-mustard and pearl-millet-mustard during 2010-11 and 2011-12 respectively (Table 4). Like in gross return, the trend of net return was similar as the cost of cultivation was same for all the treatments. Cotton-mustard and soybean–mustard cropping systems were observed to be poor in terms of net return. Benefit cost ratio was also calculated under various cropping system for

Table 4. Effect of various cropping systems on economics of mustard hybrid Coral-432 cultivation

Treatments	2010-11		2011-12	
	Net return (Rs 10^3)	B:C ratio	Net return (Rs 10^3)	B : C ratio
Fallow-mustard	44135	2.3	45690	2.4
Soybean-mustard	33759	1.8	40850	2.1
Groundnut-mustard	43110	2.3	43318	2.3
Cotton-mustard	30385	1.6	33366	1.7
Pearl-millet-mustard	47917	2.5	41138	2.1
Sesame-mustard	47821	2.5	44715	2.3
Cluster bean-mustard	43422	2.3	55209	2.9
SE (M)	3207	0.16	4220	0.2
CD at 5%	9528	0.50	12538	0.7

coral-432 mustard hybrids. The best economic viability of coral-432 was noticed under sesame-mustard, which was equally good under other cropping systems like pearl-millet-mustard, cluster bean-mustard, groundnut-mustard and fallow-mustard cropping systems. Similar finding were reported by Rao, 1999, Sinsinwar, 2002, Singh, 2006. Munda *et al*., 2007.

Conclusion

Influence of various cropping systems was found to be significant in enhancing yield attributes and yield of mustard hybrid, coral-432in the field study. Overall effect of various cropping system on seed yield of mustard hybrid Coral-432 was significant. Maximum seed yield was recorded under sesame-mustard cropping system which was significantly higher than the seed yield under all other cropping systems. The increase in yield was positive among all cropping systems except under cotton mustard, and soybean-mustard compared to fallow-mustard cropping system and maximum increase in seed yield was noticed under Sesame-mustard over fallow-mustard. Maximum biological yield was recorded under fallow-mustard cropping system which was statistically at par with biological yield and minimum harvest index under cotton –mustard. Harvest index of coral-432 was significantly influenced by various cropping systems and maximum harvest index was observed under sesame-mustard, closely followed by cluster bean -mustard cropping system. Minimum gross return was observed under cotton–mustard cropping system. Cost: benefit ratio was also calculated under various cropping system for coral-432 mustard hybrids. The best economic viability of coral-432 was recorded under sesame-mustard, which was equally at par with other cropping systems including PM-mustard, CB-mustard, groundnut-mustard and fallow-mustard.

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