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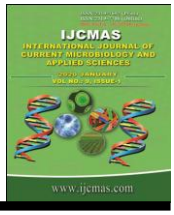

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Biomass Production and Production Efficiency of Different Soybean [*Glycine max* (L.) Merrill] based Cropping Systems in Malwa Plateau of Madhya Pradesh, India

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A B S T R A C T

Soybean is cultivated in a wider range of cropping systems due to its compatibility in various cropping systems. Its cultivation in rainfed situation and lack of diversification of rabi crop leads to lower the productivity, increases risk of crop failure. Under such circumstances, the diversification of crops under soybean based cropping system appears to be a possible way for improving the biomass productivity and production efficiency per unit area per year without jeopardizing the soil health. Keeping these points in view, a field investigation was undertaken to assess the biomass productivity and production efficiency of different cropping sequences in Malwa region during *kharif* and *rabi* cropping seasons of the year 2013-14 and 2014-15 with 14 treatments as crop-sequences in completely randomized block design with 3 replications. Maximum yield in rabi was obtained with garlic followed by the wheat. The soybean (JS 335) – garlic and soybean (JS 95-60) – garlic cropping sequences produced 30.89 & 25.14 percent higher biomass as compared to the existing cropping system soybean (JS 335) – wheat and soybean (JS 95-60) – wheat cropping system, respectively. The production efficiency of these systems was 377.9 and 384.5 per cent higher with the production efficiency under existing soybean – wheat system with soybean variety JS 335 and JS 95-60, respectively. The results of the experiment, shows that the soybean- garlic and soybean – chandrasur crop was found more efficient in Malwa plateau.

Introduction

Soybean is a prime oilseed crop of India as well as world. It is the major contributor in world oilseed economy followed by rapeseed mustard, cotton, peanut and sunflower (Sharma *et al*., 2012). In India, soybean is grown extensively in Madhya Pradesh in *kharif* season and the state is known as Soya state. Soybean (*Glycine max* L. Merrill) in rainy seasons followed by wheat (*Triticum aestivum* L.) under irrigated and chickpea (*Cicer arietinum* L.) under rainfed condition in *rabi* forms the most important prevailing cropping system on *Vertisols* of semi-arid tropics of Central India. The low productivity and higher risk of crop failure due to severe dependency on monsoon are the major problems of these cropping systems. Under such situations, the diversification of crops under soybean based cropping system appears to be a possible way for improving the productivity and profitability with maintaining the soil health. Hence, an experiment was conducted on different soybean based cropping systems to find out the maximum biomass production and enhancing the production efficiencies of different cropping sequences in Malwa Plateau of Madhya Pradesh.

Materials and Methods

The experiment was conducted in *kharif* and *rabi* cropping seasons during year 2013-14 and 2014-15 on the same sites at instructional farm of Krishi Vigyan Kendra, Neemuch (M.P.). The experimental site Neemuch lies between the parallels of latitude 24°15'–24°35' North and between the meridians of longitude 74°45'- 75°37' East, 452 meter above mean sea level and comes under Malwa Plateau Agro-climatic zone of Madhya Pradesh. This area has been identified as Agro-ecological Sub region number 10. The soil of the area was sandy clay loam in texture, slightly alkaline in reaction (pH 7.70) with normal EC (0.48 dS/m) and having medium in organic carbon contents (0.68 %), available N (266 kg/ha), available P (9.2 kg/ha) and available K (300 kg/ha). The treatments consisted of the combination of soybean variety JS 95-60 (short duration) and JS 335 (medium duration) with 7 different crops *viz*. wheat, chickpea, mustard, garlic, isabgol, ajwain and chandrasur in *rabi* season. Thus, the total 14 treatments were formed and tested in completely randomized block design with 04 replication. Due to the variability in various characteristics of rabi crops, only the statistical analysis for soybean crop was performed, however it was also performed for various cropping system parameters by using the procedure suggested by Gomez and Gomez (1984).

The crops were grown using the standard package of practices and supplied the recommended dose of fertilizers. For this study, the values of yield obtained from different crops were converted into soybean yield with the help of existing market price of produce in the locality and the soybean equivalent yield was estimated with the procedure suggested by Yadav and Newaj (1990). While, the production efficiency of each cropping sequence was worked out with the help of following formula as suggested by Tomar and Tiwari (1990):

$$\text{Production efficiency (kg/ha/day)} = \frac{\text{Soybean equivalent yield (kg/ha) of a particular crop sequence}}{\text{Total duration of all crop components of the same crop sequence (days)}}$$

The Biomass productivity of soybean based cropping systems was estimated by addition of grain and stover yield of soybean and grain/clove/seed and straw/ stover/ haulm of *rabi* season crops.

Results and Discussion

Growth parameters

The plant height was recorded significantly higher under the treatment CS_8: soybean (JS 335) - garlic (G 282) followed by under cropping sequence CS_3: soybean (JS 95-60) – chickpea (JG 130), which are statistically at par with each other (Table 1). The lowest plant height was recorded under the treatment CS_1: soybean (JS 95-60) - wheat (GW 366). The plant height of soybean was found higher with the soybean variety JS 335 as compared to soybean variety JS 95-60. The number of branches per plant in soybean was found statistically higher under treatment CS_8: soybean (JS 335) - garlic (G 282) being at par and followed by the treatment CS_2: soybean (JS 335) - wheat (GW 366) in the years 2013, 2014 and in pooled data.

The plant height of different *rabi* crops varied as per the *rabi* crop grown in the cropping sequence treatment. The plant height of wheat, chick pea, mustard was observed higher with the cropping sequence treatments with soybean variety JS 95-60, while the plant height of other crops were found more with cropping sequence treatments with soybean variety JS 335. In *rabi* crops, the values of number of branches per plant or relevant parameters were found higher with the cropping sequence treatments with soybean variety JS 95-60 in most of the cases. The plant height and branches/ plant of soybean varieties is a genetic factor, which was not much affected under different cropping sequence treatments, while the plant height and branches/leaves/ plant or tillers/meter row length of the crops grown in *rabi* season was varied with crops but not affected by residual effects of previous crop irrespective of soybean variety. It was due to different plant morphological characteristics of various crops which resulted to varied parameters of *rabi* crops.

Total biomass production

Total biomass production recorded significantly superior under cropping sequence soybean (JS 335) - garlic (14.62, 13.93 and 14.28 t/ha) followed by soybean (JS 95-60) - garlic (13.56, 13.82 and 13.69 t/ha) during the years 2013-14, 2014-15 and pooled data, respectively. This was followed by the biomass produced under soybean (JS 335/ JS 95-60) – wheat cropping sequence treatment. Soybean-mustard produced the lowest biomass during both the years in pooled data. The soybean (JS 335) – garlic and soybean (JS 95-60) – garlic cropping sequences produced 30.89 & 25.14 percent higher biomass as compared to the existing cropping system soybean (JS 335) – wheat and soybean (JS 95-60) – wheat and 157.8 & 147.6 percent more biomass over the cropping system soybean (JS 335) – chickpea and soybean (JS 95-60) – chickpea in pooled data. This could be ascribed due to higher value of growth parameters viz. plant height and branches/plant of concerning crops which produced greater grain/cloves/seed as well as stover/straw/haulm yield and resulted superior production of soybean based cropping system. These findings were on the similar lines of the findings of Ramachandra *et al.,* (2008).

Production efficiency

The production efficiencies were registered significantly highest under cropping sequence CS_8: soybean (JS 335) - garlic (G 282) with the values of 52.96 and 54.76 kg/ha/day followed by production efficiency of 52.13 and 54.67 kg/ha/day with the treatment CS_7: soybean (JS 95-60) - garlic (G 282) in the years 2013-14 and 2014-15, respectively (Table 3). Effects of both the treatments on production efficiency were not differed statistically.

Table.1 Plant height and number of branches/tillers/ leaves of soybean and different rabi crops under different cropping sequence treatments (pooled data of two years)

Treatments	Plant height (cm)		Number of branches/ leaves per plant or effective tillers per m row length	
	Soybean	Rabi crops	Soybean	Rabi crops
CS_1: Soybean (JS 95-60) - Wheat (GW 366)	42.37	94.42	3.94	86.00*
CS_2 : Soybean (JS 335) - Wheat (GW 366)	65.83	94.25	6.10	85.60*
CS_3: Soybean (JS 95-60) - Chickpea (JG 130)	44.50	52.57	4.06	6.64
CS_4: Soybean (JS 335 - Chickpea (JG 130)	64.33	52.33	5.82	6.62
CS_5: Soybean (JS 95-60) - Mustard (Pusa Jaikisan)	45.47	157.38	4.11	9.65
CS_6: Soybean (JS 335) - Mustard (Pusa Jaikisan)	64.27	152.84	6.04	9.62
CS_7: Soybean (JS 95-60) - Garlic (G 282)	44.73	39.90	4.12	8.27$^{\$}$
CS_8: Soybean (JS 335) - Garlic (G 282)	66.03	37.29	6.15	7.86$^{\$}$
CS_9: Soybean (JS 95-60) - Isabgol (JI 4)	45.80	38.02	4.31	84.27*
CS_{10}: Soybean (JS 335) - Isabgol (JI 4)	64.27	36.99	5.97	81.33*
CS_{11}: Soybean (JS 95-60) - Ajwain (Ajmer Ajwain 1)	43.03	122.82	3.96	12.52
CS_{12}: Soybean (JS 335) - Ajwain (Ajmer Ajwain 1)	64.47	120.65	5.96	12.28
CS_{13}: Soybean (JS 95-60) -Chandrasur (MC 1)	43.30	113.69	4.04	18.93
CS_{14}: Soybean (JS 335) - Chandrasur (MC 1)	64.47	113.18	5.99	19.32
SEm±	**1.76**	**-**	**0.19**	
CD (P=0.05)	**5.00**	**-**	**0.56**	**-**

*- Effective tillers per m row length, $^{\$}$ - leaves per plant

Table.2 Total biomass production of different soybean based cropping systems during the year 2013-14 and 2014-15 and in pooled data analysis

Treatment	Total biomass production (t/ha)		
	2013-14	2014-15	Pooled
T_1: soybean (JS 95-60) - wheat (GW 366)	10.96	10.92	10.94
T_2: soybean (JS 335) - wheat (GW 366)	10.87	10.95	10.91
T_3: soybean (JS 95-60) - chickpea (JG 130)	5.53	5.54	5.53
T_4: soybean (JS 335 - chickpea (JG 130)	5.52	5.55	5.54
T_5: soybean (JS 95-60) - mustard (Pusa jaikisan)	3.83	3.55	3.69
T_6: soybean (JS 335) - mustard (Pusa jaikisan)	3.65	3.67	3.66
T_7: soybean (JS 95-60) - garlic (G 282)	13.56	13.82	13.69
T_8: soybean (JS 335) - garlic (G 282)	14.62	13.93	14.28
T_9: soybean (JS 95-60) - isabgol (JI 4)	3.76	4.01	3.89
T_{10}: soybean (JS 335) - isabgol (JI 4)	3.70	3.90	3.80
T_{11}: soybean (JS 95-60) - ajwain (Ajmer ajwain 1)	6.63	6.67	6.65
T_{12}: soybean (JS-335) - ajwain (Ajmer ajwain 1)	6.43	6.77	6.60
T_{13}: soybean (JS 95-60) -chandrasur (MC 1)	6.71	6.74	6.73
T_{14}: soybean (JS 335) - chandrasur (MC 1)	6.61	6.45	6.53
SEm±	**0.10**	**0.15**	**0.13**
CD (P=0.05)	**0.28**	**0.45**	**0.37**

Table.3 Production efficiency under different cropping sequence treatments during the years 2013-14, 2014-15 and pooled analysis

Treatments	Production efficiency (kg/ha/day)		
	2013-14	2014-15	Pooled
T_1: soybean (JS 95-60) - wheat (GW 366)	10.89	11.16	11.03
T_2: soybean (JS 335) - wheat (GW 366)	11.09	11.43	11.26
T_3: soybean (JS 95-60) - chickpea (JG 130)	8.93	9.02	8.98
T_4: soybean (JS 335 - chickpea (JG 130)	9.25	9.22	9.24
T_5: soybean (JS 95-60) - mustard (Pusa jaikisan)	7.00	6.67	6.83
T_6: soybean (JS 335) - mustard (Pusa jaikisan)	7.15	7.09	7.12
T_7: soybean (JS 95-60) - garlic (G 282)	52.13	54.76	53.40
T_8: soybean (JS 335) - garlic (G 282)	52.96	54.67	53.86
T_9: soybean (JS 95-60) - isabgol (JI 4)	10.75	10.88	10.81
T_{10}: soybean (JS 335) - isabgol (JI 4)	11.13	10.70	10.91
T_{11}: soybean (JS 95-60) - ajwain (Ajmer ajwain 1)	10.37	10.20	10.28
T_{12}: soybean (JS-335) - ajwain (Ajmer ajwain 1)	10.55	10.94	10.74
T_{13}: soybean (JS 95-60) -chandrasur (MC 1)	13.62	13.19	13.40
T_{14}: soybean (JS 335) - chandrasur (MC 1)	13.60	13.15	13.38
SEm±	**0.20**	**0.23**	**0.21**
CD (P=0.05)	**0.57**	**0.67**	**0.61**
CV (5%)	10.89	11.16	11.03

The significantly lowest values of production efficiency of 7.00 and 6.67 kg/ha/day were recorded under the treatment CS_5: soybean (JS 95-60) - mustard (Pusa jaikisan) during both the years and in pooled data. The production efficiency under soybean- garlic cropping sequence treatment was observed significantly superior over the values obtained under all other treatments. The treatments with chandrasur [CS_{13}: soybean (JS 95-60) - chandrasur (MC 1) and CS_{14}: soybean (JS 335) - chandrasur (MC 1)]; with wheat [CS_2: soybean (JS 335) -wheat (GW 366) and CS_1: soybean (JS 95-60) - wheat (GW 366)]; with isabgol [CS_{10}: soybean (JS 335) - isabgol (JI 4) and CS_9: soybean (JS 95-60) - isabgol (JI 4)] and with ajwain [CS_{12}: soybean (JS-335) - ajwain (Ajmer ajwain 1) and CS_{11}: soybean (JS 95-60) - ajwain (Ajmer ajwain 1)] were on the next succeeding position in terms of production efficiency of the system. The higher production efficiency of soybean-garlic and subsequent soybean-chandrasur and soybean-wheat cropping system was because of higher soybean equivalent yield with almost similar crop duration. The similar findings were also reported by Jugnahake *et al.,* (2018) and Prajapat *et al.,* (2014) under soybean-based cropping systems in terms of soybean equivalent yield (SEY).

It can be concluded from the results of the experiment that the inclusion of horticultural crop garlic or medicinal crop chandrasur with soybean based cropping systems is more beneficial to the farmers in terms of biomass, productivity and production efficiency as compared to the existing cropping sequence treatments in the region.

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