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SY Dhale
Ph.D., Scholar, Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

BV Asewar
Head, Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Shaikh Wasim Chand
Ph.D., Scholar, Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

IAB Mirza
Assistant professor, Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

WN Narkhede
Chief Scientist, VNMKV, Parbhani, Maharashtra, India

Corresponding Author:
SY Dhale
Ph.D., Scholar, Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Effect of soybean: Pigeonpea strip cropping on growth parameters, yield attributes and yield under mechanization

SY Dhale, BV Asewar, Shaikh Wasim Chand, IAB Mirza and WN Narkhede

Abstract
The performance of soybean and pigeon pea under strip cropping was evaluated. The strips are wide enough to be managed independently, yet they are narrow enough to allow crops that are rotated annually to influence the micro climate and yield potential of adjacent crops. Mechanization as far as agriculture is concerned requires the study, manufacture, utilization, maintenance and repair of all tools, implements, machines, equipment and structures that will enable the farmer to increase the productivity of human labor economically.

The field experiment was conducted during two consecutive *kharif* seasons of 2018-19 and 2019-20 at All India Coordinated Research Project on Dryland Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (M.S.), India. The experiment consists of eight treatments *i.e.* T_1 -soybean: Pigeonpea strip of 6:3 rows, T_2 - soybean: pigeonpea strip of 6:6 rows, T_3 - soybean: pigeonpea strip of 12:9 rows, T_4 - soybean: pigeonpea strip of 12:12 rows, T_5 - soybean: pigeonpea strip of 18:12 rows,T_6 - soybean + pigeonpea (4:2) intercropping system, T_7 - sole soybean and T_8 -sole pigeon pea, in randomized block design with three replications. The data on growth parameters and yield parameters were recorded at periodical intervals and was analyzed.

The result revealed that the growth attributes the T_7-sole soybean recorded highest growth parameters and also highest recorded in case of T_8-sole pigeon pea. Among the strip cropping treatments, T_5 - soybean: pigeon pea strip of 18:12 rows recorded highest growth attributes over rest of the treatments. Based on pooled data, it is revealed that, the T_7-sole soybean significantly recorded highest (1478 kg/ha) seed yield, straw and biological yield as compared to other treatments while T_8-sole pigeon pea significantly recorded higher (1322 kg/ha) seed yield, straw and biological yield. Among the strip cropping treatments, T_5 - soybean: pigeon pea strip of 18:12 rows recorded highest seed yield, straw and biological yield over rest of the treatments.

Keywords: Growth attributes, soybean, pigeon pea, yield attributes, soybean equivalent yield, strip cropping and mechanization

Introduction
Soybean (*Glycine max*) plays an important role in the edible oil economy and is the fastest growing oilseed crop in the world. Soybean accounts for 37.4 per cent of the global oilseed area and contributes to 28 per cent of vegetable oil production (Sharma and Dupare, 2016). In India, during *Kharif* 2019 the area was 111.31 lakh hectares, production was 132.68 lakh tonnes and productivity was 1192 kg / ha and in Maharashtra during *Kharif* 2019 the area was 40.40 lakh hectares, production was 45.50 lakh tonnes and productivity was 1125 kg / ha (Source: Anonymous 2019).

Pigeonpea seeds provide essential amino acids such as lysine, tyrosine and arginine, whereas cystine and methionine are low (Saxena *et al.*, 2010) [14]. Pigeonpea seed is also rich in potassium, phosphorus, magnesium, calcium and iodine. However, the content of cystine and methionine is low. In India, during *Kharif* 2019, the area was 47.80 lakh hectares, production was 33.20 lakh tonnes and productivity was 751 kg / ha and in maharashtra during *Kharif* 2019, the area under pigeon pea was 12.61 lakh ha with production 8.34 lakh tonnes and productivity 662 kg / ha (Source: Anonymous 2019).

Strip cropping is like any other intercropping strategy based on the management of plant interactions to maximize growth and productivity caused by efficient use of plant growth resources such as light, water and nutrients Hauggaard-Nielsen (2009) [8].

Production suffers because of improper seed bed preparation, depth of seed, delay in sowing and harvesting. Mechanization enables the conservation of input through precision metering, ensuring better distribution, reducing quantity needed for better response and prevention of losses or wastage of inputs applied. Uniform seed spacing and depth result in better germination and emergence and increase yield (20 to 25%) by minimizing competition between plants for available light, water and nutrients (Karayel and Ozmerzi, 2008) [10]. In traditional method of sowing proper placement of seed in field cannot achieved by labour. But it can be possible with mechanical and sowing with appropriate metering mechanism.

Materials and Methods

The present study was conducted at experimental farm of All India Coordinated Research Project on Dryland Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth Parbhani (M.S.) India, during two consecutive *kharif* seasons of 2018 and 2019. The experiment was laid down in randomized block design with three replications and gross and net plot size are variable as per the treatments. The experiment consist of eight treatments *viz.* T_1 -soybean: pigeonpea strip of 6:3 rows, T_2 - soybean: pigeonpea strip of 6:6 rows, T_3 - soybean: pigeonpea strip of 12:9 rows, T_4 - soybean: pigeonpea strip of 12:12 rows, T_5 - soybean: pigeonpea strip of 18:12 rows, T_6 - soybean + pigeonpea (4:2) intercropping system, T_7 - sole soybean and T_8 - sole pigeon pea. Total rainfall received during 2018-19 and 2019-20 were 781.4 mm and 970.4 mm, respectively. The experimental soil was clay (54.16 and 54.68 per cent clay), slightly alkaline in nature (pH 7.78 and 8.09), low in nitrogen availability N_2- 150.74 and 162.43 kg / ha), medium in available phosphorus (P_2O_5-10.78 and 12.80 kg / ha), low in organic carbon (0.48 and 0.55 per cent) and high in available potassium (K_2O- 485.90 and 510.18 kg / ha) during 2018 and 2019, respectively. The variety selected were MAUS-162 for soybean and pigeon pea variety BDN-711, especially released for mechanical cultivation. Crop was sown using tractor mounted *seed-cum-ferti-drill*, on 27th June and 5th July during 2018 and 2019 respectively. The total rainfall received during both the years of study was 781.4 mm during 2018 and 970.4 mm during 2019 which was optimum for crop growth. The recommended practices for plant protection were followed during both the years. The data on growth parameters and yield parameters were recorded at periodical intervals and was analyzed.

Results and Discussion

Growth attributes

Soybean: Based on pooled data, the data presented in table-1 indicated that highest dry matter accumulation plant-1at harvest was observed with sole soybean (T_7) i.e. 25.55, it was found to be at par with soybean: pigeon pea strip of 6:6 rows (T_2), soybean: pigeon pea strip of 12:12 rows (T_4) and soybean: pigeon pea strip of 18:12 rows (T_5). This might be due to higher leaf area resulted in more photosynthetic activities and more accumulation of carbohydrates which in turn increased dry matter accumulation. The similar result regarding dry matter accumulation per plant of soybean was observed by Murungu *et al.* (2011) [13].

The maximum number of pods plant^{-1}at harvest was observed with sole soybean (T_7) *i.e.* 32.79 it was found to be at par with soybean: pigeon pea strip of 6:6 rows (T_2), soybean: pigeon pea strip of 12:12 rows (T_4) and soybean: pigeon pea strip of 18:12 rows (T_5) (Table 1). There is a complementary interaction between two crops in strip rows and to reduce soil erosion. The similar results regarding number of pods plant^{-1} of soybean were reported by Javed *et al.* (2019) [9]

Pigeonpea

Data presented in table-1 revealed that highest dry matter accumulation plant^{-1} at harvest was observed with sole pigeon pea (T_8) *i.e.* 112.20 g it was found to be at par with soybean: pigeon pea strip of 12:12 rows (T_4) and soybean: pigeon pea strip of 18:12 rows (T_5). The similar result regarding dry matter accumulation plant^{-1} of pigeon pea were observed by Murungu *et al.* (2011) [13].

Data presented in table-1 indicated maximum number of pods per plant at harvest was observed with sole pigeon pea (T_8) *i.e.* 109.50 it was found to be at par with soybean: pigeon pea strip of 6:3 rows (T_1), soybean: pigeon pea strip of 6:6 rows (T_2), soybean: pigeon pea strip of 12:12 rows (T_4) and soybean: pigeon pea strip of 18:12 rows (T_5). The similar result regarding number of pods plant^{-1} of pigeon pea was reported by Javed *et al.* (2019) [9]

Yield attributes

Soybean

Among the different treatments, the sole soybean recorded significantly higher weight of pods, number of seeds per plant, weight of seeds per plant and test weight might be due to mechanical sowing with *seed-cum- ferti - drill* provided fertilizer near root zone at proper depth of moisture in soil increased the nutrients availability to soybean that promoted both vertical as well as lateral growth and induced more number of flowers, pods. Exner (1999) [7] suggested that yield was increased due to less soil erosion lowering general nutrient emissions, weed management aspects and less disease and pests. The similar results were reported by Dhakad and Khedkar (2014) [4]. The data indicated in table 2.

Among the strip cropping treatments, maximum weight of pods, number of seeds per plant, weight of seeds per plant and test weight was observed in soybean: pigeon pea strip of 18:12 rows which was at par with soybean: pigeon pea strip of 6:6 rows and soybean: pigeon pea strip of 12:12 rows. It can be due to also improved use of resources like light, water, nutrients and land reported by Hauggaard-Nelson (2009) [8]

However, among the strip cropping treatments, the seed yield produced significantly higher with soybean: pigeon pea strip of 18:12 rows. (Table 3). The maximum straw yield and biological yield was produced significantly higher with sole soybean and soybean: pigeon pea strip of 18:12 rows over the other treatments. Profound effect on seed and straw yield ha^{-1} was noted due to different strip-cropping practices. The probable reason behind the increase in seed yield could be due to more favorable overall growth and yield attributes due to favorable seed beds, improved aeration and scope for light interception. The similar results had been reported by Lesoing and Francis (1999) [11] and Murungu *et al.* (2011) [13].

Pigeonpea

The different treatments, the sole soybean recorded significantly higher weight of pods, number of seeds per plant, weight of seeds per plant and test weight as compared to rest of the treatment.

Among the different strip cropping treatments, maximum

weight of pods, number of seeds per plant, weight of seeds per plant and test weight was observed in T_5- soybean: pigeon pea strip of 18:12 rows which was at par with soybean: pigeon pea strip of 6:3 rows, soybean: pigeon pea strip of 6:6 rows and soybean: pigeon pea strip of 12:12 rows. Strip cropping provided well-drained and well-aerated rooting medium on wet soils, which helps to maintain proper air and water balance. The similar results were revealed by Garcia (1991a) [6], Liu *et al.* (2016) [12].

Pigeon pea sown as sole crop recorded higher seed yield, straw yield, biological yield and harvest index over the other treatments. Among the strip cropping treatments (Soybean: pigeon pea strip of 18:12 rows) produced higher seed yield, straw yield, biological yield and harvest index over the rest of the other strip cropping treatments. (Table 3). The probable reason behind the increase in seed yield could be due to more favorable overall growth and yield attributes due to favorable seed beds, improved aeration, scope for light interception, the benefit of more preserved seed moisture and its support at critical growth stages such as flowering, pod initiation and development. As well as due to better soil and plant conditions provided by strip rows leading to increased growth and yield parameters. Results were confirmed by Ae *et al.* (1990) [2].

Table 1: The growth attributes of soybean and pigeon pea as influenced by different treatments at harvest (Pooled data of two year)

Trt No.	Treatments	Soybean Pigeon pea			
		Dry matter accumulation plant^{-1}(gm)	No. of pods plant^{-1}	Dry matter accumulation plant^{-1}(gm)	No. of pods plant^{-1}
T_1	Soybean:pigeon pea strip of 6:3rows	19.95	27.09	92.58	97.23
T_2	Soybean:pigeon pea strip of 6:6rows	22.29	28.31	94.48	101.68
T_3	Soybean:pigeon pea strip of 12:9rows	18.87	26.44	91.30	93.76
T_4	Soybean:pigeon pea strip of 12:12rows	23.18	29.10	102.57	104.79
T_5	Soybean:pigeon pea strip of 18:12rows	23.61	30.22	104.28	106.88
T_6	Soybean+pigeonpea (4:2) intercropping system	17.88	25.53	90.39	89.25
T_7	Sole soybean	25.55	32.79	--	--
T_8	Sole pigeon pea	--	--	112.20	109.50
SE (m)+		1.02	1.96	1.02	5.21
C.D. at 5%		2.96	4.75	2.96	15.34
General Mean		21.62	28.42	21.62	98.26

Table 2: Yield attributes of soybean and pigeonpea as influenced by different treatments. (Pooled data of two years)

Trt No.	Treatments	Soybean				Pigeon pea			
		Weight of pod plant^{-1}(g)	Number of seeds plant^{-1}	Seeds weight plant^{-1}(g)	Test weight (g)	Weight of pod plant^{-1}(g)	Number of seeds plant^{-1}	Seeds weight plant^{-1}(g)	Test weight (g)
T_1	Soybean:pigeon pea strip of 6:3rows	8.51	55.10	3.65	81.30	30.29	268	29.43	102.07
T_2	Soybean:pigeon pea strip of 6:6rows	8.61	60.98	4.81	82.01	39.77	301	31.89	102.43
T_3	Soybean:pigeon pea strip of 12:9rows	8.01	54.65	3.37	80.68	36.29	254	25.87	100.90
T_4	Soybean:pigeon pea strip of 12:12rows	9.43	64.69	5.45	82.19	40.87	308	32.57	102.62
T_5	Soybean:pigeon pea strip of 18:12rows	10.06	65.66	5.65	82.35	42.37	318	34.10	102.78
T_6	Soybean+pigeonpea(4:2) intercropping system	7.57	52.83	3.20	80.54	35.64	241	25.24	100.68
T_7	Sole soybean	10.65	66.93	5.82	82.49	--	--	--	--
T_8	Sole pigeon pea	--	--	--	--	43.33	332	34.72	102.96
SE (m)+		0.56	2.88	0.32	0.67	1.90	14.12	1.55	1.00
C.D. at 5%		1.46	8.47	0.96	NS	5.57	41.52	3.56	NS
General Mean		8.97	60.12	4.56	81.65	39.51	289	30.47	102.06

Table 3: Seed yield, straw yield, biological yield and harvest index of soybean and pigeon pea as influenced by different treatments during 2018-19, 2019-20 and in pooled analysis

Trt No.	Treatments	Soybean				Pigeon pea			
		Seed yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)	Seed yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest Index (%)
T_1	Soybean:pigeon pea strip of 6:3rows	1024	1699	2722	37.58	875	2478	3353	26.05
T_2	Soybean:pigeon pea strip of 6:6rows	1068	1800	2868	37.21	947	2543	3490	27.12
T_3	Soybean:pigeon pea strip of 12:9rows	949	1646	2595	36.55	841	2383	3208	26.14
T_4	Soybean:pigeon pea strip of 12:12rows	1111	1870	2981	37.26	965	2592	3557	27.12
T_5	Soybean:pigeon pea strip of 18:12rows	1163	1908	3071	37.85	1033	2656	3689	27.95
T_6	Soybean+pigeonpea(4:2) intercropping system	911	1595	2506	36.32	773	22.78	3050	25.20
T_7	Sole soybean	1478	2205	3682	40.11	--	--	--	--
T_8	Sole pigeon pea	--	--	--	--	1322	3210	4533	29.13

SE(m)±	44.79	61.89	122	--	45.89	66.00	138	--
CD at 5%	132.01	186	368	--	137.00	201.10	410	--
General mean	1101	1818	2918	37.42	965	2591	3556	26.96

Conclusion

In all the treatment sole soybean and sole pigeonpea recorded highest growth attributes and yield attributes as compared to other treatments. Among the strip cropping treatment soybean: pigeon pea strip of 18:12 rows recorded highest growth parameters and yield attributes and yield as compared to other strip cropping treatments.

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