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Effect of deficit irrigation and conservation tillage on growth of soybean (*Glycine max* L.) In soybean-wheat cropping system

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Abstract
An investigation was carried out at Post Graduate Institute Research Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra (India) on “Conservation agriculture for improving crop productivity and water use efficiency in soybean–wheat cropping system under deficit irrigation” during 2017 and 2018. The soil of experimental field was sandy loam in texture. The experiment was laid out in split plot design with of four main plot treatments of irrigation scheduling on the basis of depletion of available soil moisture (DASM)] *viz*., I_1 – 40% of DASM, I_2 – 50% of DASM, I_3 – 60% of DASM, I_4 – As per critical growth stages (CGS) and two sub plot treatments of tillage practices *viz*., T_1 – Zero tillage, T_2 – Conventional tillage during two consecutive years. The result revealed that mean higher growth attributes *viz*., plant height (20.86/22.57, 52.69/54.28, 55.06/56.08 and 55.32/56.29 cm during 2017 and 2018 at 30, 60, 90 DAS and at harvest respectively), number of branches plant^{-1} (2.73/2.99, 6.49/6.90, 6.85/7.30 during 2017 and 2018 at 30, 60 and 90 DAS respectively), number of leaves plant^{-1} (7.37/7.77, 22.65/23.79 and 7.58/7.09 during 2017 and 2018 at 30, 60 and 90 DAS respectively), leaf area plant^{-1} (3.41/4.40, 32.08/33.63 and 3.75/4.49 dm^2 during 2017 and 2018 at 30, 60 and 90 DAS respectively) and dry matter plant^{-1} (5.37/6.56, 32.34/33.33, 34.91/36.04 and 35.43/36.95 g during 2017 and 2018 at 30, 60, 90 DAS and at harvest respectively) recorded under scheduling of irrigation at 40 per cent of DASM with conventional tillage practice to *kharif* soybean (*Glycine max* L.).

Keywords: Growth, deficit irrigation, irrigation scheduling, conventional tillage, zero tillage

Introduction

Soybean (*Glycine max* L. Merill) being a potentially high yielding crop can play a greater role boosting oil seed production in the country. Madhya Pradesh is known as the “Soybean State” of India. Soybean plant is classified as oilseed rather than pulse crop as approximately 85 per cent of the world’s soybean crop is processed into soybean meal and vegetable oil. It contains above 40 per cent protein of superior quality with all the essential amino acid particularly glycine, tryptophan and lysine. Soybean also contains about 20 per cent oil with an important fatty acid, lecithin and vitamin A and D (Anon, 2020).

Conservation agriculture aims to conserve, improve and make more efficient use of natural resources through integrated management of available soil, water and biological resources combined with external inputs. It contributes to environmental conservation as well as to enhanced and sustained agricultural production. In conventional tillage, the repeated ploughings is not only involve high expenditure but also consume time which many a times delay the sowing of the crops resulting in low yields in intensive cropping system where gap between the harvest of one crop and sowing of the next crop is very short. Zero tillage techniques is an ecological approach for soil surface management and seed bed preparation resulting in minimizing cost of cultivation, less weed problem, better crop residue management and higher yield and quality of produce etc.

The application of water below the evapotranspiration (ET) requirement is termed deficit irrigation. Irrigation supply under deficit irrigation is reduced relative to that needed to meet maximum ET. Therefore, water demand for irrigation can be reduced and the water saved can be diverted for alternative uses. Soybean followed by wheat is an important cropping system on semi-arid tropical *Vertisols* of Central India. Soybean-wheat cropping system, one among the 30 major cropping systems prevalent in the country, is predominantly practiced in the states of Madhya Pradesh, Maharashtra and Rajasthan. Therefor keeping these facts in view field study was planned and carried out.

Material and Methods

The field experiment was conducted during *kharif* season 2017 and 2018 at the Research Farm of Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri (M.S.), situated at 19^0 48'N and 19^0 57'N Latitude and 74^0 32'E and 74^0 19'E longitude and altitude is 511 m above mean sea level. The topography of experimental field was levelled and well drained. The meteorological data on important weather parameters during the crop growth period for the year 2017 and 2018 was recorded at Meteorological Observatory located at AICRP on Irrigation Water Management Project, M.P.K.V., Rahuri.

The experiment was conducted in split plot design with three replications during *kharif* season in a fixed lay out. The treatment consists of four main plot treatments of irrigation scheduling was done on the basis of the depletion of available soil moisture (DASM) and critical growth stages of crops (CGS) soybean *viz*., I_1 – 40% of DASM, I_2 – 50% of DASM, I_3 – 60% of DASM, I_4 – As per CGS (branching, flowering and pod development) and two sub plot treatments of tillage practices *viz*., T_1 – Zero tillage, T_2 – Conventional tillage for *kharif* soybean. In case of conventional tillage one ploughing and harrowing was carried out. The gross plot size was 16.20 m x 3.20 m. The soybean variety KDS-344 (phule agrani) was grown at row to row spacing 30 cm and plant to plant spacing 10 cm by using seed rate 75 kg ha^{-1}. The 15 t FYM was applied before sowing, while recommended dose of fertilizer @ 50:75:45 kg N, P_2O_5, K_2O ha^{-1} given in the form of urea, single super phosphate and muriate of potash, respectively during 2017 and 2018. In soybean Pendimethalin 30 EC @ 1 to 1.5 kg a.i. ha^{-1} was applied as pre-emergence followed by two hand weeding at 15 DAS and 35 DAS followed by application of Imazethapyr 10% SL @ 0.1 to 0.15 kg a.i. at 21 DAS in zero tillage plot during both the years of study.

The various growth parameters *viz*., plant height (cm), number of branches $plant^{-1}$, number of leaves $plant^{-1}$, leaf area $plant^{-1}(dm^2)$, dry matter $plant^{-1}$ (g) in soybean were recorded on five randomly selected plants. The leaf area was calculated using the formula suggested by Jain and Misra (1966) [8]. The growth observations were recorded at an interval of 15 days commencing from 30 DAS till 90 DAS and at harvest during both years.

Scheduling of irrigation

First common irrigation was applied immediately after sowing to ensure the better germination of soybean. The depletion of available soil moisture was measured by soil moisture meter. The periodical depletion was monitored as per irrigation treatment. Based on percent depletion of available moisture the depth of irrigation at each irrigation was worked out. The volume of water was calculated based on area to be irrigated (m^2) as per treatment. After knowing the total volume of water, the discharge rate was measured by using 90^0V Notch weir and worked out time required for irrigation by using fallowing formula.

$$\text{Time (Sec.)} = \frac{\text{Area } (m^2) \text{ x Depth of irrigation (m)}}{\text{Discharge (lit. Sec.)}}$$

Result And Discussion

Plant height (cm)

Effect of irrigation scheduling

Irrigation scheduling at 40% of DASM to soybean recorded significantly higher plant height (Table 1) at 30, 60, 90 DAS and at harvest. However, it was at par with irrigation scheduling at 50% of DASM at 30 and 90 DAS and at harvest during second year. This might be due to optimum moisture maintain in root rhizosphere throughout crop growth period which increase the availability and uptake of nutrients by the crop resulted in increases the cell division and multiplication in meristematic and zone of elongation region thereby increases the plant height. Significantly minimum plant height was observed under irrigation scheduling at 60% of DASM. The results were supported by Jahanfar Daneshian *et al*. (2011) [7], Antonia *et al.* (2016) [2] and Shoukun Dong (2019) [13].

Effect of tillage practices

Conventional tillage practice recorded significantly higher plant height of soybean at 30, 60, 90 DAS and at harvest than zero tillage practice during both the years (Table 1). This is might be due to better soil physical condition in respect of porosity and water holding capacity which maintains the congenial environment in crop root zone throught crop growth period resulted in increase in plant height. These results are in accordance with those reported by, Danijel *et al*. (2006) [6], Lasisi and Aluko (2009) [10], Kombiok and Buah (2013) [9].

Number of branches $plant^{-1}$

Effect of irrigation scheduling

The number of branches $plant^{-1}$ in soybean (Table 2) were registered significantly higher in treatment scheduling of irrigation at 40% of DASM at 30, 60 and 90 DAS during 2017 and 2018. However, it was at par with irrigation scheduling at 50% of DASM at 60 DAS during first year. This might be due to root zone of the crop always remains at field capacity which helps to increase the translocation of photosynthates in plant resulted in higher growth attributes. These results are in the line of Atti *et al*. (2004) [3] and Cigdem Demirtas *et al*. (2010) [5]. Irrigation scheduling at 60% of DASM registered significantly minimum number of branches $plant^{-1}$ at all the stages of observations during both the years.

Effect of tillage practices

Data presented in Table 2 concluded that number of branches $plant^{-1}$ of soybean was recorded significantly higher in conventional tillage than zero tillage at 30, 60 and 90 DAS during both the years. This might be due to its effect on soil physical and chemical properties which enhances moisture and nutrient absorption by crop results in better growth of plants. These results are in accordance with those reported by Danijel *et al*. (2006) [6] and Lasisi and Aluko (2009) [10].

Number of leaves $plant^{-1}$

Effect of irrigation scheduling

Data from Table 3 revealed that the numbers of leaves $plant^{-1}$ were recorded significantly maximum in irrigation scheduling at 40% of DASM to soybean crop than irrigation scheduling at 60% of DASM and irrigation as per critical growth stages at all the crop growth stages during both the years. However, it was at par with irrigation scheduling at 50% of DASM at 60 and 90 DAS during first year and at 30, 75 and 90 DAS during second year of study. This might be because of more than 50 per cent depletion of available soil water induces moisture stress which reduce number of leaves resulted into the decreased node emergence rate and accelerated leaf senescence. These results were confirmed by Atti *et al*. (2004) [3] and Chathurika Wijewardana *et al.* (2019) [4].

Effect of tillage practices

The conventional tillage practice recorded significantly higher number of leaves plant^{-1} than zero tillage practice at all the crop growth stages during both the years (Table 3). This might be due to congenial environment available in respect of soil moisture and nutrients for growth and developments of soybean crop. These results are in conformity with those reported by Lasisi and Aluko (2009) [10] and Parshotam Kumar *et al*. (2018) [12].

Leaf area plant^{-1} (dm^2)

Effect of irrigation scheduling

Data from Table 4 revealed that the scheduling of irrigation at 40% of DASM to soybean crop registered significantly higher leaf area plant^{-1} than rest of the irrigation scheduling treatments. Significantly minimum leaf area plant^{-1} was observed under irrigation scheduling at 60% of DASM at all the stages of observations during both the years. This might be due to dehydration of protoplasm and a decline in relative turgidity, which accompanied by a loss of turgor and decreased cell division due to moisture stress under irrigation scheduling at 50 and 60% of DASM and as per critical growth stages, while irrigation scheduling at 40% of DASM provides sufficient moisture at all the crop growth stages for luxurious crop growth resulted in production of maximum number of leaves and obtained higher leaf area plant^{-1}. These results are supported by Sincik *et al*. (2008) [14], Antonia *et al.* (2016) [2] and Chathurika Wijewardana *et al.* (2019) [4].

Effect of tillage practices

The leaf area plant^{-1} in soybean registered maximum under conventional tillage practice than zero tillage practice at all the crop growth stages during both the years (Table 4). This might be due to minimum soil compaction increases the porosity and aeration in the root zone for longer period resulted in more uptake of moisture and nutrients for growth and development of crop ultimately increases leaf area plant^{-1}. These results are in conformity with those reported by Danijel *et al*. (2006) [6] and Ali Monsefi *et al*. (2013) [11].

Dry matter (g) plant^{-1}

Effect of irrigation scheduling

Irrigation scheduling at 40% of DASM registered significantly higher dry matter plant^{-1} during both the years. However, it was at par with irrigation scheduling at 50% of DASM at harvest during first year and at 30 and 90 DAS during second year. Irrigation scheduling at 60% of DASM registered significantly minimum dry matter plant^{-1}. The higher dry matter accumulation with frequent irrigation treatment i.e. irrigation scheduling at 40% of DASM might be due to luxurious crop growth without any moisture stress upto physiological maturity stage increases all the growth attributes *viz*. plant height, number of leaves plant^{-1}, leaf area plant^{-1} and number of branches which ultimately produces higher dry matter than other treatments of irrigation scheduling. These results are in agreement with those reported by Afsana Mimi *et al*. (2016) [1], Chathurika Wijewardana *et al*. (2019) [4].

Effect of tillage practices

Data presented in Table 5 implicited that significantly higher dry matter plant^{-1} of soybean recorded in conventional tillage practice than zero tillage practice due to better availability of moisture and nutrients results in better growth of crop which enhances biomass production by plant. These results are in accordance with Lasisi and Aluko (2009) [10], Monsefi Ali *et al*. (2013) [11] and Parshotam Kumar *et al*. (2018) [12].

Table 1: Periodical plant height of soybean as influenced by different treatments

Treatments	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
	2017				2018			
Irrigation scheduling – I								
I_1: 40% of DASM	22.48	56.57	58.42	58.76	24.57	58.76	60.38	60.64
I_2: 50% of DASM	21.33	53.86	56.20	56.53	23.02	55.27	57.21	57.41
I_3: 60% of DASM	19.35	49.94	52.32	52.41	20.57	50.87	52.76	52.91
I_4: As per CGS	20.29	50.40	53.29	53.59	22.14	52.20	53.97	54.20
SE (m) ±	0.14	0.40	0.50	0.47	0.77	0.98	1.08	0.92
C.D. at 5%	0.47	1.37	1.73	1.62	2.66	3.40	3.75	3.18
Tillage practices – T								
T_1: Zero tillage	19.85	51.83	53.54	53.87	21.59	53.64	54.63	54.82
T_2: Conventional tillage	21.87	53.56	56.58	56.77	23.56	54.91	57.52	57.76
SE (m) ±	0.07	0.21	0.31	0.30	0.08	0.08	0.30	0.71
C.D. at 5%	0.23	0.68	1.02	0.99	0.28	0.26	0.97	2.32
Interactions								
Between two sub plots means at same level of main plot means (I XT)								
SE (m) ±	0.14	0.41	0.62	0.60	0.16	0.15	0.59	1.42
C.D. at 5%	NS	1.36	NS	NS	NS	0.51	NS	NS
Between two main plots means at same level of sub plot means (T x I)								
SE (m) ±	0.16	0.49	0.66	0.63	0.78	0.98	1.16	1.36
C.D. at 5%	NS	1.67	NS	NS	NS	3.14	NS	NS
General mean	20.86	52.69	55.06	55.32	22.57	54.28	56.08	56.29

Table 2: Periodical number of branches plant^{-1} in soybean as influenced by different treatments

Treatments	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
	2017			2018		
Irrigation scheduling – I						
I_1: 40% of DASM	3.36	7.35	7.80	3.94	8.13	8.43

I_2: 50% of DASM	2.90	6.71	7.05	3.08	7.13	7.62
I_3: 60% of DASM	2.05	5.42	5.75	2.10	5.58	5.91
I_4: As per CGS	2.61	6.49	6.81	2.82	6.77	7.24
SE (m) ±	0.12	0.24	0.21	0.07	0.22	0.22
C.D. at 5%	0.41	0.84	0.71	0.25	0.75	0.77
Tillage practices – T						
T_1: Zero tillage	2.17	5.71	6.06	2.55	6.26	6.82
T_2: Conventional tillage	3.28	7.27	7.65	3.43	7.55	7.78
SE (m) ±	0.08	0.11	0.14	0.05	0.10	0.03
C.D. at 5%	0.25	0.37	0.45	0.16	0.33	0.10
Interactions (I x T)						
Between two sub plots means at same level of main plot means (I XT)						
SE (m) ±	0.15	0.22	0.27	0.09	0.20	0.06
C.D. at 5%	NS	NS	NS	NS	NS	NS
Between two main plots means at same level of sub plot means (T x I)						
SE (m) ±	0.16	0.29	0.28	0.01	0.25	0.22
C.D. at 5%	NS	NS	NS	NS	NS	NS
General mean	2.73	6.49	6.85	2.99	6.90	7.30

Table 3: Periodical number of leaves plant^{-1} in soybean as influenced by different treatments

Treatments	**30 DAS**	**60 DAS**	**90 DAS**	**30 DAS**	**60 DAS**	**90 DAS**
	2017			**2018**		
Irrigation scheduling – I						
I_1: 40% of DASM	8.90	26.28	8.56	9.14	27.77	9.21
I_2: 50% of DASM	8.03	24.13	8.22	8.29	25.06	8.77
I_3: 60% of DASM	5.64	18.38	5.63	6.62	19.68	5.99
I_4: As per CGS	6.92	21.79	7.90	7.04	22.67	7.99
SE (m) ±	0.07	0.64	0.15	0.31	0.60	0.32
C.D. at 5%	0.23	2.23	0.51	1.08	2.08	1.10
Tillage practices – T						
T_1: Zero tillage	6.71	21.43	6.98	7.18	22.82	7.54
T_2: Conventional tillage	8.04	23.87	8.17	8.36	24.76	8.44
SE (m) ±	0.11	0.18	0.17	0.06	0.17	0.07
C.D. at 5%	0.34	0.59	0.55	0.19	0.55	0.22
Interactions (I x T)						
Between two sub plots means at same level of main plot means (I XT)						
SE (m) ±	0.21	0.36	0.33	0.11	0.33	0.13
C.D. at 5%	NS	NS	NS	NS	NS	NS
Between two main plots means at same level of sub plot means (T x I)						
SE (m) ±	0.16	0.69	0.28	0.32	0.64	0.33
C.D. at 5%	NS	NS	NS	NS	NS	NS
General mean	7.37	22.65	7.58	7.77	23.79	7.99

Table 4: Periodical leaf area plant^{-1} in soybean as influenced by different treatments

Treatments	**30 DAS**	**60 DAS**	**90 DAS**	**30 DAS**	**60 DAS**	**90 DAS**
	2017			**2018**		
Irrigation scheduling – I						
I_1: 40% of DASM	4.21	36.51	4.61	5.33	38.55	5.23
I_2: 50% of DASM	3.37	33.12	4.02	4.47	34.55	4.72
I_3: 60% of DASM	2.92	27.86	2.87	3.77	28.99	3.77
I_4: As per CGS	3.14	30.85	3.49	4.05	32.42	4.26
SE (m) ±	0.18	0.53	0.17	0.14	0.42	0.10
C.D. at 5%	0.61	1.83	0.58	0.47	1.44	0.34
Tillage practices – T						
T_1: Zero tillage	2.95	31.03	3.42	3.90	32.85	4.12
T_2: Conventional tillage	3.87	33.14	4.07	4.91	34.40	4.87
SE (m) ±	0.09	0.12	0.09	0.04	0.13	0.11
C.D. at 5%	0.28	0.39	0.30	0.12	0.41	0.36
Interactions (I x T)						
Between two sub plots means at same level of main plot means (I XT)						
SE (m) ±	0.17	0.23	0.18	0.07	0.32	0.22
C.D. at 5%	NS	NS	NS	NS	NS	NS
Between two main plots means at same level of sub plot means (T x I)						
SE (m) ±	0.21	0.55	0.21	0.14	0.55	0.18
C.D. at 5%	NS	NS	NS	NS	NS	NS
General mean	3.41	32.08	3.75	4.40	33.63	4.49

Table 5: Periodical dry matter plant^{-1} of soybean as influenced by different treatments

Treatments		30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
		2017				2018			
Irrigation scheduling – I									
I_1:	40% of DASM	6.19	34.66	37.30	37.91	7.63	35.87	38.59	40.48
I_2:	50% of DASM	5.41	33.47	36.02	36.75	7.14	34.02	37.20	37.88
I_3:	60% of DASM	4.71	29.26	31.75	32.10	5.38	30.41	32.76	32.84
I_4:	As per CGS	5.18	31.96	34.56	34.95	6.11	33.02	35.71	36.61
	SE (m) ±	0.12	0.27	0.33	0.46	0.14	0.50	0.62	0.71
	C.D. at 5%	0.43	0.92	1.16	1.59	0.49	1.61	1.84	2.04
Tillage practices – T									
T_1:	Zero tillage	4.47	31.21	33.75	34.33	6.05	33.37	35.90	36.64
T_2:	Conventional tillage	6.28	33.47	36.06	36.52	7.08	34.28	36.22	37.66
	SE (m) ±	0.08	0.07	0.12	0.11	0.10	0.23	0.41	0.37
	C.D. at 5%	0.26	0.23	0.40	0.36	0.34	0.66	NS	1.09
Interactions (I x T)									
Between two sub plots means at same level of main plot means (I XT)									
	SE (m) ±	0.15	0.13	0.24	0.21	0.20	0.63	0.57	0.49
	C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS
	Between two main plots means at same level of sub plot means (T x I)								
	SE (m) ±	0.16	0.28	0.37	0.48	0.20	0.64	0.68	0.73
	C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS
	General mean	5.37	32.34	34.91	35.43	6.56	33.33	36.04	36.95

Conclusion

Based on two years of experimentation it could be concluded that the scheduling of irrigation at 40 per cent of DASM and conventional tillage practice to *kharif* soybean obtained higher growth parameters *viz*., plant height (cm), number of branches plant^{-1}, number of leaves plant^{-1}, leaf area plant^{-1} (dm^2) and dry matter plant^{-1} (g) in soybean-wheat cropping system.

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