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EFFECT OF SOWING DATES AND WEED CONTROL METHODS ON YIELD COMPONENTS OF SOYBEAN (*Glycine max* L. MERRILL)

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ABSTRACT

Soybean is one of the most important legumes in the world. Sowing date and weeds are considered as the major determinants of soybean yield. In order to study the influence of sowing date and weed control methods on the yield attributes of soybean cv. BARI Soybean-6, a field experiment was conducted during December, 2012 to June, 2013 at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. The different sowing dates (18th December, 2nd January, 17th January and 1st February) and weeding methods (no weeding, two hand weeding, hand hoe weeding and chemical control by Whip Super 9 EC (Fenoxaprop-P-ethyl: $C_{18}H_{16}C_lNO_5$)) showed significant effect on number of plants m^{-2}, number of pods plant^{-1}, pod length, number of seeds pod^{-1}, 1000-seed weight, stover yield, biological yield and harvest index of soybean. Results revealed that sowing on 2 January gave the highest number of pods plant^{-1}, seeds pod^{-1}, 1000-seed weight, stover and biological yield (31.50, 1.93, 117.70 g, 2.74 and 4.91 t ha^{-1}, respectively). The weeds were effectively controlled by two hand weeding (20 and 40 DAS) which produced the maximum number of pods plant^{-1}, pod length, seeds pod^{-1}, stover and biological yield (32.75, 3.17 cm, 1.91, 2.74 t ha^{-1} and 4.97 t ha^{-1}, respectively) which were statistically similar (30.92, 2.98 cm, 1.85, 2.63 t ha^{-1} and 4.82 t ha^{-1}, respectively) with herbicide application. Interaction effect showed that highest number of pods plant^{-1}, seeds pod^{-1}, 1000-seed weight, stover and biological yield (37.67, 2.00, 125.80 g, 3.10 and 5.60 t ha^{-1}, respectively) were obtained from 2 January sowing when the crop was weeded by hand at 20 and 40 DAS.

Key words: Biological yield, harvest index, soybean, stover yield, 1000-seed weight.

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INTRODUCTION

Soybean (*Glycine max* L. Merrill) is popularly known as golden bean which is used both as a pulse and oilseed crop (Thakare *et al.,* 2006) and a new prospective crop for Bangladesh (Rahman *et al.,* 2011). There are some factors that influence the production and development of soybean. Among the factors photoperiod, solar radiation, temperature, humidity, rainfall and soil fertility affect the crop (Barros *et al.,* 2009), which makes sowing time the main cultivation component that affects the cycle and productivity of soybean (Motta *et al.,* 2000; Barros *et al.,* 2003). Days to flowering, days to maturity and the length of reproductive and regulative periods of development are reduced due to delayed planting (Board *et al.,* 1992).

Low soil fertility and weed-crop competition result in reduced yield of soybean (Sodangi *et al.,* 2011). Weeds are a major problem in soybean and causes significant loss in yield and quality. Weeds not only share environmental resources but also hamper the harvesting process, liberate allelopathic substances, host of many insects, pest, pathogens and nematodes that cause different diseases. Daugovish *et al.* (2003) and Gazziero *et al.* (2004) revealed that soybean-weed competition decreased soybean yield up to 80% around the world.

For successful weed control in soybean crop, two hand hoeings are suggested (Rakesh and Shirvastava, 2002; Singh and Jolly, 2004). Two hand hoeing are more effective for weed control in soybean field resulting increased seed yield (Ahmed *et al.,* 2001). Now-a-days, manual labor shortage and wage scale rise significantly. It is anticipated that manual weeding increased the production cost about 40-60% (Remison, 1979). In this situation, weed control by chemical is a better option to reduce expenditure and to boost the soybean yield. For effective annual weed control and to get high legume and soybean yield, selective herbicides may be the good alternative (Hassanein, 2000; El-Metwally and Saad El-Din, 2003; Sha, 2004; Abd El-Razik, 2006). Under these circumstances effective weed control methods needed to be developed to reduce yield loss due to weed infestation. However, since soybean is rather a new crop, the research in this line is highly scarce in Bangladesh. Keeping this in view the present study was aimed to find out the optimum sowing date and effective weed control method to ensure yield maximization.

MATERIALS AND METHODS

Site description, soil and climatic condition

A field experiment was carried out at the Agronomy Research Field, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh situated at 23°74′N latitude and 90°35′E longitude at an altitude of 8.6

meter above the sea level during the period from December 2012 to June 2013. The soil of the experimental site was silt loam in texture with pH of 6.4, organic carbon of 0.68 %, total nitrogen was 0.08 %, available phosphorus was 10.99 mg/kg, available potassium 0.05 meq/100g and available sulphur of 10.5 mg/kg. The experimental site is under subtropical humid climatic conditions and the detailed mean maximum, minimum temperature and rainfall was presented in Fig. 1.

Experimental treatments

The experiment was consisted of four sowing dates *viz.,* 18 December (S_1), 2 January (S_2), 17 January (S_3), and 1 February (S_4); and four weed management treatments i.e. no weeding (control), two hand weeding (20 and 40 DAS) (W_1), hand hoe weeding at 20 and 40 DAS (W_2) and chemical control by Whip Super 9 EC (Fenoxaprop-P-ethyl) @ 615 ml ha^{-1} at 20 DAS (W_3) as post-emergence herbicide.

Design, plot size, planting material

Split plot design was followed in the experiment with three replications. The individual plot size was 4 m x 2.5 m with inter plot and block spacing of 0.50 and 1 m, respectively. Sowing date was assigned to main plots and weed control treatments were assigned to sub plots. BARI Soybean-6 was used as the planting material in this experiment.

Fertilizer application and seed sowing

During the time of final land preparation, all the fertilizers were applied following BARI recommended dose (55 kg ha^{-1} N, 165 kg ha^{-1} P, 110 kg ha^{-1} K, 100 kg ha^{-1} S) (BARI, 2011). Seeds were sown in 30 cm rows and 5 cm within lines following as per treatment dates.

Biological yield

Biological yield was calculated by using the following formula:

Biological yield= Seed yield + Stover yield

Harvest index (%)

Harvest index is the relationship between seed yield and biological yield (Gardner *et al.,* 1985). It was calculated by using the following formula:

$$\text{HI (\%)} = \frac{\text{Seed yield}}{\text{Biological yield}} \times 100$$

Statistical analysis

Statistical analysis was done by using the MSTAT-C computer program (Russel, 1994). Analysis of Variance (ANOVA) test following by Duncan's Multiple Range Test (DMRT) was used to determine the difference among the treatment means ($p \leq 0.05$).

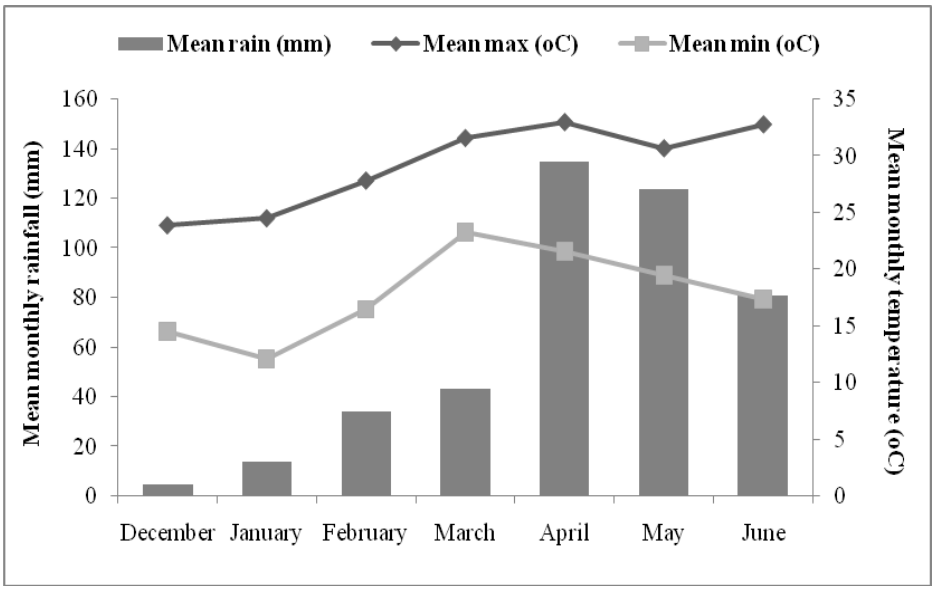

Figure 1. Mean maximum, minimum temperature and rainfall during the experimental period

RESULTS AND DISCUSSION

Number of plants m^{-2}

Data showed that sowing on 2 January and 17 January produced the highest number of plants m^{-2} (61.33) and the lowest (42.00) was counted in plots when sowing was done on 1 February (Table-1). These results corroborate with the findings of Egli and Bruening (2000), who found that early sowing decrease the initial stands of plants.

Weed management practices significantly influenced the number of plants m^{-2} of soybean (Table-1). Two hand weeding (20 and 40 DAS) produced the highest number of plants m^{-2} (61.33) and the lowest (47.83) was found from unweeded treatment which was statistically at par with two hand hoe weeding (20 and 40 DAS). Compared to other treatments, twice hand weeding (20 and 40 DAS) was effective in weed control because crop-weed competition was lighter and limited, and the resources were available to encourage soybean growth. These results are also supported by Galal (2003) and Mohamed (2004).

Interaction of sowing date and weed control strategies exerted significant effect on number of plants m^{-2} of soybean (Table-1). Sowing on 2 January and 17 January with twice hand weeding (20 and 40 DAS) gave the highest number of plants m^{-2} (73.00) whereas, the lowest (37.67) was found from combination of 1 February sowing with

no weeding treatment which was statistically at par with combinations of 1 February and twice hand hoe weeding (20 and 40 DAS), 1 February and Whip Super 9 EC, 18 December and no weeding, 1 February and twice hand weeding (20 and 40 DAS).

Number of pods plant^{-1}

Number of pods plant^{-1} was significantly influenced by different sowing dates of soybean (Table-1). The highest number of pods plant^{-1} (31.50) was obtained from sowing on 2 January which was statistically similar with sowing on 18 December and 17 January and the lowest (24.42) was noted from 1 February sowing. Wafaa *et al.* (2002) also observed that number of pods plant^{-1} was significantly affected by sowing date. Early planting date increased the pods in the main stem, primary and secondary branches which ultimately increased total number of pods plant^{-1} than the late planting date (Pedersen and Lauer, 2004; Salahi *et al.,* 2006; Mokhtarpoor *et al.,* 2008).

Number of pods plant^{-1} of soybean was significantly affected by different weed management practices (Table-1). Twice hand weeding (20 and 40 DAS) produced the highest number of pods plant^{-1} (32.75) which was statistically at par with application of herbicide Whip Super 9 EC whereas, the lowest (24.50) was observed from no weeding. Severe weed competition in the no weed control treatment decreased the number of pods plant^{-1}. Weed free treatments formed more number of pods than no weeding. Jain (2000) also found maximum number of pods in no weed control plots. This might be due to weed free treatments provided adequate amount of moisture and nutrients for healthy plant growth which favored the pod formation. Similar results were reported by Pittelkow *et al.* (2009).

Variation was observed for number of pods plant^{-1} due to the interaction effect of sowing date and weed control methods of soybean (Table-1). Sowing on 2 January with twice hand weeding (20 and 40 DAS) combination produced the maximum number of pods plant^{-1} (37.67) which was statistically similar with 17 January sowing with hand weeding at 20 and 40 DAS combination. The minimum number of pods plant^{-1} (21.33) was observed from 1 February with no weeding which was statistically at par with combinations of 17 January with no weeding and twice hand hoe weeding (20 and 40 DAS), 1 February with twice hand hoe weeding (20 and 40 DAS) and with Whip Super 9 EC.

Pod length (cm)

Sowing date showed non-significant effect on pod length of soybean (Table-1). Numerically the largest pod length (3.10 cm) was found in 2 January sowing and the shortest (2.83 cm) was observed from 1 February. Decreased vegetative growth and increased

reproductive growth favored the pod length. These results supported by Weaver *et al.* (1991).

The pod length of soybean affected significantly by weed control methods (Table-1). Lengthy pods (31.68 cm) was found from twice hand weeding (20 and 40 DAS) plots which was statistically similar with application of Whip Super 9 EC and two hand hoe weeding (20 and 40 DAS). The shortest pod length (2.80 cm) was observed from without weeding treatment which was statistically similar with two hand hoe weeding (20 and 40 DAS) and chemical treatment Whip Super 9 EC.

Interaction of sowing date and weed control strategies showed non-significant effect on pod length of soybean (Table-1). Numerically the largest pod length (3.24 cm) was found from 18 December with twice hand weeding (20 and 40 DAS) and the smallest (2.56 cm) was obtained from 1 February with application of Whip Super 9 EC.

Number of seeds pod^{-1}

Data revealed that sowing on 2 January produced the maximum seeds pod^{-1} (1.93) which was statistically at par with 18 December and the minimum (1.61) was found from 1 February sowing (Table-1). Number of seeds pod^{-1} depends on genotype and it is independence of environmental factors and just special environmental stress in period of establishment of seed affect on it. Salahi *et al.* (2006); Woong and Yamakawa (2006) reported similar results.

Weed control by hand weeding at 20 and 40 DAS produced maximum seeds pod^{-1} (1.91) which was statistically similar with Whip Super 9 EC and two hand hoe weeding (20 and 40 DAS) as shown in Table-1. Minimum number of seeds pod^{-1} (1.70) was observed from no weeding which was statistically similar with twice hand hoe weeding (20 and 40 DAS). Weed competition hampered light interception which causing shading and also decreasing resource availability and photosynthesis which resulted compensate relationship between yield components (Carson *et al.,* 1982), with decreasing seeds pod^{-1}. Similar results were observed by Rathman and Miller (1981).

Number of seeds pod^{-1} of soybean significantly influenced by sowing date and weed management practices (Table-1). Sowing at 2 January with two hand weeding (20 and 40 DAS) produced the highest number of seeds pod^{-1} (2.00) which was statistically similar with 18 December along with all the weeding treatments, 2 January with no weeding, 2 January with twice hand hoe weeding (20 and 40 DAS). Minimum number of seeds pod^{-1} (1.46) was observed in plots where sowing was done on 1 February with no weeding which was statistically at par with 1 February with other weed control methods.

1000-seed weight

1000-seed weight of soybean varied significantly by different sowing date (Table-2). Sowing on 2 January produced the highest 1000-seed weight (117.70 g) which was statistically at par with 18 December and the lowest (105.60 g) was found from 1 February sowing which was statistically at par with sowing on 17 January. This might be due to the short vegetative growth period and long reproductive and grain filling period that significantly increased the 1000-seed weight. These results are confirmed by Pedersen and Lauer (2004), who reported that early sowing of soybean got more growth period to accumulate more photo-assimilates which increased the average seed weight than late sowing. Hamzeh *et al.* (2004) and Shafigh *et al.* (2006) also found similar results.

1000-seed weight of soybean varied significantly by weed control methods (Table-2). The highest 1000-seed weight (119.00 g) was counted from plots with twice hand weeding (20 and 40 DAS) and the lowest (104.20 g) was recorded from no weeding which was statistically similar with two hand hoe weeding (20 and 40 DAS) and Whip Super 9 EC. Several studies showed that higher crop-weed competition significantly reduced the 1000-seed weight of soybean (Silva *et al.,* 2008; Pittelkow *et al.,* 2009). On the other hand, reduced weed competition due to weed control methods increased the availability of nutrients and 1000-seed weight of soybean. The results are similar with Vyas and Jain (2003).

Interaction of sowing date and weed control method showed significant effect on 1000-seed weight of soybean (Table-2). The highest 1000-seed weight (125.80 g) was observed from 2 January with two hand weeding (20 and 40 DAS) which was statistically similar with 18 December with two hand weeding (20 and 40 DAS), 2 January with other weeding treatments, 18 December with Whip Super 9 EC. The lowest 1000-seed weight (97.87 g) was obtained from 1 February sowing with no weeding which was statistically similar with 17 January and all the weed management practices except twice hand weeding (20 and 40 DAS), 1 February along with other weed control strategies, 2 January with no weeding.

Stover yield

The maximum stover yield (2.74 t ha^{-1}) was obtained from 2 January which was statistically at par with 18 December and 17 January whereas, the lowest (2.04 t ha^{-1}) was observed from 1 February which was statistically at par with 17 January and 18 December (Table-2). It might be the results of higher plant height, number of plants m^{-2}, pods $plant^{-1}$and higher dry matter accumulation $plant^{-1}$ which resulted evidently due to the profuse branching.

It was observed that the highest stover yield (2.74 t ha^{-1}) was recorded from twice hand weeding (20 and 40 DAS) which was statistically similar with chemical application Whip Super 9 EC and the minimum (2.02 t ha^{-1}) was produced from without weeding (Table-2). Peer *et al.* (2013) also recorded superior stover yield in different weed control treatments, especially in no weeding treatment.

The highest stover yield (3.10 t ha^{-1}) was obtained from combination of 2 January with twice hand weeding (20 and 40 DAS) which was statistically similar with 2 January with Whip Super 9 EC, 18 December with two hand weeding (20 and 40 DAS) and 18 December with Whip Super 9 EC. Whereas, the lowest stover yield (1.70 t ha^{-1}) was found from combination of 1 February with no weeding which was at par with 1 February with two hand hoe weeding (20 and 40 DAS), 18 December with no weeding and 1 February with Whip Super 9 EC (Table-2).

Biological yield

Significant variation was observed in biological yield of soybean due to the effect of sowing date as shown in Table-2. The maximum biological yield (4.91 t ha^{-1}) was found from 2 January which was statistically similar with that of 18 December; and the lowest (3.67) was obtained from 1 February. Biological yield decreased in late planting date; it might be due to flowers appeared in late and produced terminal buds, leaves, new growth and the plant stopped the reproductive growth. Lopez-Billido *et al.* (2008) reported a reduction in biological yield due to delayed planting. Similar results were also observed by Calvino *et al.* (2003); Ahmed *et al.* (2010); Ngalamu *et al.* (2012).

Effect of weeding showed significant variation with regard to biological yield of soybean (Table-2). Twice hand weeding (20 and 40 DAS) led the maximum biological yield (4.97 t ha^{-1}) which was statistically similar with Whip Super 9 EC application, while the lowest (3.41 t ha^{-1}) was obtained from no weeding treatment. Peer *et al.* (2013) reported that different weed control treatments favorably influenced the biological yield. They recorded up to 52% higher biological yield in weed free treatments compare to no weed control plots.

It was evident from Table-2 that interaction effect of sowing on 2 January with weed control by twice hand weeding (20 and 40 DAS) produced the maximum biological yield (5.60 t ha^{-1}) which was statistically at par with 2 January sowing plus Whip Super 9 EC application, and 18 December sowing with hand weeding at 20 and 40 DAS. Whereas, the lowest (2.90 t ha^{-1}) was obtained from 1 February with no weeding which was statistically at par with the sowing date of 18^{th} December plus no weeding.

Harvest index

Sowing date showed non-significant effect on harvest index of soybean (Table-2). Numerically the highest harvest index (44.61 %) was observed from 1 February and the lowest (43.86 %) was found from 18 December. Heydari zadeh and Khajepour (2007) revealed that harvest index is affected by planting date. Early planting date results in higher harvest index (Pedersen and Lauer, 2004; Mirza khani *et al.,* 2002) which was contradictory with the present findings; but Talavaky (1996) reported that harvest index was not affected by planting date which agrees with this experiment.

Significant harvest index (45.44 %) was observed from Whip Super 9 EC which was statistically at par with twice hand weeding and hand hoe weeding (20 and 40 DAS); whereas, the lowest (40.76 %) was recorded from control (without weeding) treatment (Table-2). Bhandiwaddar and Itnal (1998) reported that harvest index of soybean varied with different weed control methods over no weed control treatment.

Harvest index of soybean varied significantly due to different sowing date and weed control treatments (Table-2). The highest harvest index (46.72 %) was obtained from sowing on 1 February with weed control by Whip Super 9 EC which was statistically similar to sowing at 2 January with all the weeding treatments. The lowest harvest index (38.84 %) was obtained from 17 January with no weeding which was statistically at par with 18 December with all the weed management practices, 17 January with other weed control methods, 1 February with no weeding, 1 February with twice hand weeding (20 and 40 DAS) and 1 February with twice hand hoe weeding (20 and 40 DAS).

CONCLUSION

Considering the results of the present experiment, it may be concluded that yield parameters of soybean decreased with delay planting. Early sowing favored the yield components of BARI soybean-6. On the other hand, two hand weeding (20 and 40 DAS) was the best weed control practice. Therefore, 2nd January sowing and twice hand weeding (20 and 40 DAS) showed better performance compared to other treatments.

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Table-1. Effect of sowing date and/or weed control method on yield attributes of soybean

Treatments	Plants m^{-2} (no.)	Pods $plant^{-1}$ (no.)	Pod length (cm)	Seeds pod^{-1} (no.)
Sowing date				
S_1	50.58 b	29.75 a	2.99	1.92 a
S_2	61.33 a	31.50 a	3.10	1.93 a
S_3	61.33 a	29.33 a	2.97	1.77 b
S_4	42.00 c	24.42 b	2.83	1.61 c
SE	2.40	0.78	NS	0.03
CV (%)	15.46	9.44	10.21	6.31
Weed control method				
W_0	47.83 c	24.50 c	2.795 b	1.70 b
W_1	61.33 a	32.75 a	3.168 a	1.91 a
W_2	51.50 bc	26.83 b	2.949 ab	1.78 ab
W_3	54.58 b	30.92 a	2.977 ab	1.85 a
SE	1.81	0.73	0.10	0.05
Sowing date × Weed control method				
S_1W_0	46.33 d-f	26.67 d-f	2.65	1.80 a-c
S_1W_1	52.33 b-d	31.00 b-d	3.24	1.99 a
S_1W_2	49.67 b-e	28.33 c-f	2.97	1.92 ab
S_1W_3	54.00 b-d	33.00 bc	3.12	1.97 a
S_2W_0	53.67 b-d	26.33 d-f	3.03	1.86 a-c
S_2W_1	73.00 a	37.67 a	3.13	2.00 a
S_2W_2	58.67 bc	29.00 c-e	3.11	1.88 a-c
S_2W_3	60.00 b	33.00 bc	3.12	1.97 a
S_3W_0	53.67 b-d	23.67 fg	2.78	1.66 b-d
S_3W_1	73.00 a	35.33 ab	3.13	1.90 a-c
S_3W_2	58.67 bc	26.00 e-g	2.85	1.72 a-d
S_3W_3	60.00 b	32.33 bc	3.11	1.81 a-c
S_4W_0	37.67 f	21.33 g	2.72	1.46 d
S_4W_1	47.00 c-f	27.00 d-f	3.18	1.73 a-d
S_4W_2	39.00 ef	24.00 fg	2.87	1.59 cd
S_4W_3	44.33 d-f	25.33 e-g	2.56	1.66 b-d
SE	3.61	1.45	NS	0.09
CV (%)	11.62	8.76	11.51	8.49

Data shown are the means (n = X; ± SE) of the measured traits. Data were pooled of three experimental units. Columns with similar letter showing no significant difference; $p \leq 0.05$, ANOVA with DMRT test). NS: non-significant. S_1=18 December, S_2=2 January, S_3=17 January, S_4=1 February. W_0=No weeding, W_1= Two hand weeding (20 and 40 DAS), W_2= Two hand hoe weeding (20 and 40 DAS), W_3= Whip Super 9 EC (Fenoxaprop-P-ethyl)

Table-2. Effect of sowing date and/or weed control method on 1000-seed weight, stover yield, biological yield and harvest index of soybean

Treatments	1000-seed weight (g)	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Sowing date				
S_1	111.90 ab	2.55 ab	4.53 ab	43.93
S_2	117.70 a	2.74 a	4.91 a	44.20
S_3	108.70 b	2.39 ab	4.30 b	44.42
S_4	105.60 b	2.04 b	3.67 c	44.69
SE	3.94	0.15	0.15	NS
CV (%)	12.31	21.56	12.24	14.95
Weed control method				
W_0	104.20 b	2.02 c	3.41 c	40.76 b
W_1	119.00 a	2.74 a	4.97 a	44.87 a
W_2	109.20 b	2.32 b	4.21 b	44.89 a
W_3	111.50 b	2.63 a	4.82 a	45.44 a
SE	2.54	0.07	0.07	1.07
Sowing date × Weed control method				
S_1W_0	106.20 b-d	2.00 f-h	3.29 hi	39.21 b
S_1W_1	121.60 ab	2.89 ab	5.26 ab	45.06 ab
S_1W_2	107.50 b-d	2.48 b-e	4.45 de	44.27 ab
S_1W_3	112.20 a-d	2.81 a-c	5.13 bc	45.22 ab
S_2W_0	112.50 a-d	2.25 d-g	3.99 fg	43.36 ab
S_2W_1	125.80 a	3.10 a	5.60 a	44.64 ab
S_2W_2	116.00 a-c	2.55 b-e	4.60 de	44.57 ab
S_2W_3	116.30 a-c	3.06 a	5.44 ab	43.93 ab
S_3W_0	100.10 cd	2.11 e-g	3.45 h	38.84 b
S_3W_1	115.30 a-c	2.57 b-d	4.76 cd	46.01 ab
S_3W_2	109.40 a-d	2.33 d-g	4.26 ef	45.07 ab
S_3W_3	110.10 a-d	2.54 b-e	4.74 cd	46.41 ab
S_4W_0	97.87 d	1.70 h	2.90 i	41.38 ab
S_4W_1	113.20 a-d	2.41 c-f	4.27 ef	43.56 ab
S_4W_2	103.90 cd	1.93 gh	3.55gh	45.92 ab
S_4W_3	107.30 b-d	2.11 e-h	3.96 fg	46.72 a
SE	5.09	0.135	0.146	2.136
CV (%)	7.94	9.70	5.83	8.36

Data shown are the means (n = X; ± SE) of the measured traits. Data were pooled of three experimental units. Columns with similar letter showing no significant difference; $p \leq 0.05$, ANOVA with DMRT test. S_1=18 Dec, S_2=2 Jan, S_3=17 Jan, S_4=1 Feb. W_0=No weeding, W_1= Two hand weeding (20 and 40 DAS), W_2= Two hand hoe weeding (20 and 40 DAS), W_3= Whip Super 9 EC (Fenoxaprop-P-ethyl)

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