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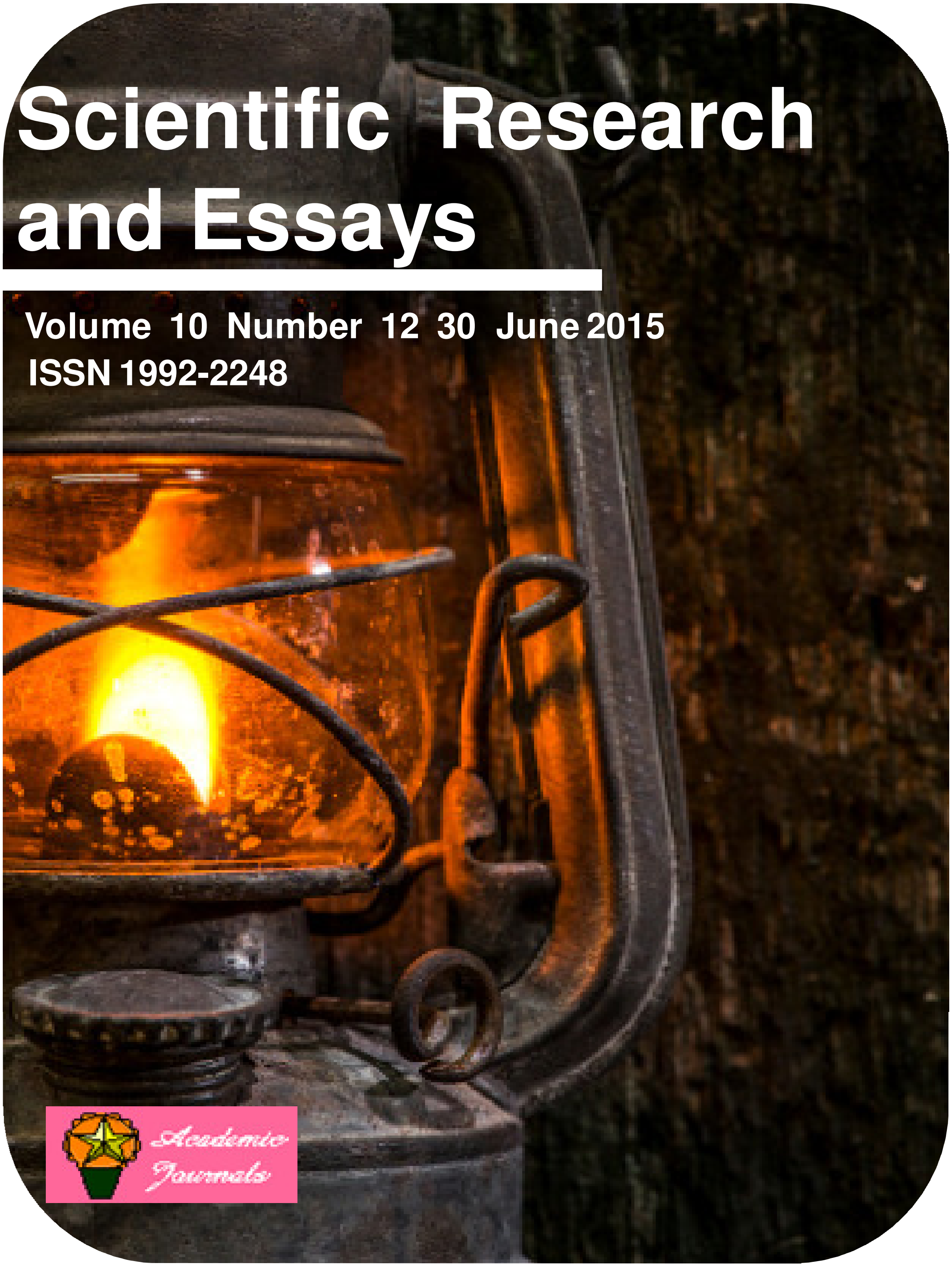

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Scientific Research and Essays

Full Length Research Paper

Seasonal incidence of major insect- pests and their biocontrol agents of soybean crop (*Glycine max* L. Merrill)

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The major insect-pests observed attacking soybean variety JS 335 were girdle beetle, *Obereopsis brevis*; tobacco caterpillar, *Spodoptera litura*; green semilooper, *Chrysodeixis acuta*; whitefly, *Bemisia tabaci* and jassids, *Empoasca kerri.* The peak activity of girdle beetle (1.0 damaged plant per meter row) was observed during first week of October. Whereas the peak activity of caterpillar pests that is, *S. litura* (2.5 larvae per meter row) and *C. acuta* (0.7 larvae per meter row) was recorded during second fortnight of August and that of sucking pests that is, *B. tabaci* (3.2 whiteflies per plant) and *E. kerri* (3.4 jassids per plant) was recorded during last week of August and Second week of August, respectively. The biocontrol agent's three species of lady bird beetle, *Menochilus sexmaculata*, *Coccinella septumpunctata* and *Coccinella transversalis* and orb weaver spider, *Neoscona* sp. were found predating mainly upon whiteflies and jassids. Whereas, lynx spider, *Oxyopes* sp. and a predatory pentatomid bug, *Eocanthecona furcellata* was noticed sucking the body sap of lepidopterous larvae. The peak activity of lady bird beetle in second week of August and September with 0.4 grub and adult per plant, whereas the predatory pentatomid bug and spider is both last week of August with 1.1 and 1.2 bugs and spider per plant respectively.

Key words: Girdle beetle, caterpillar, sucking pests and soybean.

INTRODUCTION

Soybean (*Glycine max*) is a wonder crop of twentieth century. It is an excellent source of protein and oil. It is a two-dimensional crop as it contains about 40 to 42% high quality protein and 20 to 22% oil. Gangrade (1976) reported that over 99 insect species attacking soybean crop at Jabalpur. Vieira et al. (2011) observed that when *Bemisia tabaci* occurs in large populations, the plants weakened by the extraction of large amounts of sap. Researchers in many parts of India have confirmed that seed yield and seed quality are being adversely affected by major insect pests viz. girdle beetle, tobacco caterpillar, green semilooper, jassids and white fly. Sum common insect pest complex infesting soybean crops are Green Semilooper, Tobacco Caterpillar, White fly, Girdle beetle etc. reported by Kumawat (2007). The predatory pentatomid bug *Eocanthecona furcellata* (Wolff) is

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Table 1. Insect-pests fauna observed on soybean variety JS-335 during *kharif,* 2012.

S/No.	Common Name	Systemic position	Damaging stage	Range of incidence	Status of peak activity
1	Girdle beetle	*Obereopsis brevis* (Coleoptera : Cerambycidae)	Grub	0.3 to 1.0 (Grubs / m. row)	First week of October
2	Tobacco caterpillar	*Spodoptera litura* (Lepidoptera : Noctuidae)	Caterpillar	0.3 to 2.5 (Caterpillars / m. row)	Third week of August
3	Green semilooper	Chrysodeixis *acuta* (Lepidoptera : Noctuidae)	Caterpillar	0.2 to 0.7 (Caterpillars / m. row)	Third week of August
3	White fly	*Bemisia tabaci* (Hemiptera : Aleyrodidae)	Nymph and Adult	0.1 to 3.2 (flies / plant)	Last week of August
4	Jassids	*Empoasca kerri* (Hemiptera : Cicadellidae)	Nymph and Adult	0.9 to 3.4 (Jassids / plant)	Second week of August

regarded as a potential biological control agent against lepidopteran pests in Southeast Asia reported by Nyunt (2008). Most true predators have relatively broad diets, some degree of preference is almost always present, Begon et al. (1996). There is evidence that generalist arthropod predators choose to eat certain prey to balance their amino-acid requirements and therefore may be affected by previous feeding (Greenstone, 1979). While most ecological studies on spiders as potential biocontrol agents in agroecosystems have focused on Lycosidae, Linyphiidae, and Araenidae, much less is known about Thomisidae (Dean et al., 1987; Agnew and Smith, 1989; Lang et al., 1999; Symondson et al., 2002; Vichitbandha and Wise, 2002; Romero and Vasconcello- Neto, 2003; Harwood et al., 2004). In Michigan, Gardiner et al. (2011) observed that the exotic coccinellids *Coccinella septempunctata* and *Harmonia axyridis* were the most abundant predators found in soybean field.

MATERIALS AND METHODS

Seasonal incidence of major insect pests and their biocontrol agents of soybean crop was recorded at 7 days interval from field during *kharif*, 2012 at Indira Gandhi Krishi Vishwavidyalaya; Raipur, Chhattisgarh (India). Soybean variety JS-335 was sown on 10th July 2012. In this experiment number of plants infested by girdle beetle and the number of caterpillar pests was counted from ten randomly selected one meter row-length. To record the observations on sucking pests, that is, whiteflies and jassids were recorded from randomly selected twenty plants. From each plant, insect count on five leaves was recorded; three from upper and two from middle part of the plant. Later, mean number of sucking pests per plant was calculated. Biocontrol agents (particularly lady bird beetle, spider and predatory pentatomid bug) population was recorded from randomly selected twenty plants. Later, mean number of biocontrol agents per plant was calculated.

RESULTS

The studies on the seasonal incidence of insect pests of soybean crop on variety JS-335 revealed that the occurrence of insect pest complex commenced from 25 days of sowing. Observation of pest incidence that is, population of each insect was recorded on soybean crop as per the procedure mentioned under “materials and methods.” During the course of study, five insects species, viz., Girdle beetle, tobacco caterpillar, green semilooper, whiteflies and jassids were observed and causing damage at various growth stages of soybean crop. Among the biocontrol agents, three predators, namely, lady bird beetles, a predatory pentatomid bug and spiders were mainly observed preying on them (Tables 1, 2 and 3).

Pest succession studies

During the course of study, five insects species, viz., Girdle beetle, *Obereopsis brevis* tobacco caterpillar, *Spodoptera litura*, green semilooper, *Chrysodeixis acuta*, Jassids, *Empoasca kerri* and white flies, *Bemisia tabaci* were recorded as the major pests on soybean, variety JS- 335 causing damage at various stages of the crop. All these insects made their first appearance on the crop to a greater or lesser extent in the last week of July. The activity of girdle beetle increased gradually with peak density of the Cerambycid in the first week of October recoding 1.0 damaged plants per meter row with seasonal mean of 0.24 damaged plants. The density of lepidopterous caterpillars increased gradually with peak population of 3.2 larvae per meter row during the third week of August and seasonal mean of 1.33 larvae per meter row among the sucking pests, whitefly was observed in higher numbers than jassids. The peak density of sucking pests was observed during second week of August with 6.5 sucking pests/plant and seasonal mean of 3.94 white flies and jassids per plant.

Three species of lady bird beetle, *M. sexmuculata, Coccinella transversalis* and *C. septumpunctata* were recorded as the major bioagents of the sucking pests. They first appeared on the crop in the last week of July with 0.1 grub and adult per plant. They were observed feeding on nymphs and adults of jassids and whiteflies.

Table 2. Predatory fauna observed on soybean variety JS -335 during *kharif,* 2012.

S/ No.	Common name	Systemic position	Insect pests preyed	Range of incidence	Status of peak activity
1	Lady bird beetle-	a) *Menochilus sexmuculata* b) *Coccinella septumpunctata* c) *Coccinella_transversalis* (Coleopteran : Coccinellidae)	Whiteflies and jassids Whiteflies and jassids Whiteflies and jassids	0.1 to 0.4 (Beetles/meter row)	Second week of August and September
2	Pentatomid bug	*Eocanthecona furcellata* (Hemiptera: Pentatomidae)	Lepidopterous caterpillars	0.3 to 1.1 (bugs/meter row)	Last week of August
3	Spiders (a) Lynx spider (b) Orb weaver spider	*Oxyopes satticus* (Araneae: Oxyopidae) *Neoscona sp.* (Araneae: Araneidae)	Lepidopterous caterpillars Whiteflies and Jassids	0.4 to 1.2 (Spiders/meter row)	Last week of August

Table 3. Seasonal incidence of major insect pests and natural enemies of soybean on variety JS-335 during *Kharif*, 2012.

Date of observation	Incidence per meter row length				Mean population/plant			No. of predators/ plant		
	No. of Girdle beetle damaged plants	No. of caterpillars								
		S. litura	*C. acuta*	Total	*B. tabaci*	*E. kerri*	Total	Coccinellid beetle	Pentatomid bug	Spiders
30.07.2012	0.0	0.3	0.0	0.3	0.1	0.0	0.1	0.1	0.0	0.0
06.08.2012	0.0	0.6	0.2	0.8	1.0	0.9	1.9	0.2	0.3	0.4
13.08.2012	0.0	1.5	0.4	1.9	3.1	3.4	**6.5**	**0.4**	0.8	0.6
20.08.2012	0.0	2.5	0.7	**3.2**	2.9	2.7	5.6	0.3	0.8	0.7
27.08.2012	0.0	2.1	0.5	2.6	3.2	3.0	6.2	0.3	**1.1**	**1.2**
03.09.2012	0.0	1.2	0.5	1.7	2.8	3.1	5.9	0.2	0.7	0.7
10.09.2012	0.3	1.0	0.2	1.2	2.7	2.0	4.7	**0.4**	0.6	0.7
17.09.2012	0.3	0.8	0.2	1.0	2.5	2.9	5.4	0.2	0.1	0.3
24.09.2012	0.2	0.6	0.0	0.6	2.0	1.0	3.0	0.0	0.4	0.4
01.10.2012	0.8	0.8	0.0	0.8	2.5	1.4	3.0	0.2	0.4	0.4
08.10.2012	**1.0**	0.6	0.0	0.6	0.8	0.2	1.0	0.1	0.3	0.7
Seasonal mean	**0.24**	**1.09**	**0.25**	**1.33**	**2.15**	**1.87**	**3.94**	**0.22**	**0.50**	**0.55**

Their activity continued till the first week of October and peak activity was observed in second week of August and September with 0.4 grub and adult per plant.

The Pentatomid bug, *E. furcellata* was observed to suck the body sap of caterpillar pests. It made its first appearance on the crop in the first week of August with 0.3 bugs per plant. Its density increased gradually with the peak population of 1.1 bugs in the last week of August and a seasonal mean of 0.50 bugs.

Besides the lady bird beetle and pentatomid bug, two predatory spiders, namely, lynx spider and orb weaver spider were found preying upon lepidopterous caterpillars and sucking pests, respectively. *Oxyopes* sp. is a hunting spider, whereas, *Neoscona* sp. is a web building spider. The spiders first appeared on the crop in the first week of August with mean population of 0.4 spiders per plant. It coincided with the appearance of host insects on the crop. They were active throughout the growth period of the crop, till the first week of October. Their population ranged from 0.4 to 1.2 spiders with a seasonal mean of 0.55 spiders per plant.

DISCUSSIONS

Based on pests succession studies on soybean variety JS-335, girdle beetle *(O. brevis)*, caterpillar pests (*S. litura* and *C. acuta*) and sucking pests (*B. tabaci* and *E. kerri*) were observed as key pests inflicting substantial damage to the crop. The *S. litura* is the major insect pests of soybean as compared to other caterpillar pests.

In present investigation the peak activity of *S. litura, C. acuta, B. tabaci* and *E. kerri* was observed during, the third week of August, third week of August, last week of August and second week of August, respectively. Related observations were recorded by Netam (2010) and Kujur (2011). Thus, these observations are in conformity with the present findings.

Netam (2010) observed that density of lepidopterous caterpillars increased gradually with peak population of 5.0 larvae per meter row during the last week of August and seasonal mean of 3.22 larvae per meter row among the sucking pests, whitefly was observed in higher numbers than jassids. The peak density of sucking pests was observed during third week of September with 4.4 sucking pests/plant and seasonal mean of 3.62 white flies and jassids per plant. Preying upon the sucking insects, were two species of lady bird beetle, *Coccinella septumpunctata* and *Menochilus sexmaculata* and two species of spiders, lynx spider and an unidentified golden preying spider. The latter was also a recorded preying on lepidopterous larvae.

Kujur (2011) reported that peak activity of girdle beetle was noticed during the second week of September with 3.1 number of girdle beetle damaged plants per meter row and a seasonal mean of 1.76. The defoliators, *S. litura* and *C. acuta* recorded their peak activity during last week of August (3.2 larvae per meter row) and during third week of August (1.2 larvae per meter row) with a seasonal mean of 1.58 and 0.40 larvae per meter row, respectively. Among sucking pests, the population of whitefly reached its peak of 3.1 whiteflies per plant during last week of September with a seasonal mean of 1.95 whiteflies per plant. Whereas, the jassid attained its peak density during last week of August (1.2 jassids per plant) with a seasonal mean of 0.90 jassid per plant. Among the predators, lady bird beetles – *M. sexmaculata* and *C. septumpunctata* and spider *Neoscona* sp. were observed preying on whiteflies and jassids; whereas, another spider *Oxyopes* sp. and a predatory pentatomid bug *Eocanthecona furcellata* were observed feeding on the lepidopterous larvae.

Singh and Singh (1987) studied the incidence and damage caused by the Noctuidae *Chrysodeixis acuta* to soybean pods and flowers in July-September 1984 in Madhya Pradesh, India. Larvae appeared during the 1st week of August and the maximum population was observed on 14th September.

Population densities of *Spodoptera litura* (Fab.) and *Spilosoma obliqua* Walker during the crop growth period were in maximum around the second half of October. However, density of *Plusia orichalcea* (Fab.) was higher during the later part of September or early October. Significant correlations were observed between population densities of some insect species as reported by Kumar et al. (1998). Paik et al. (2007) observed that *S. litura* occurred significantly in late August in soybean field. Patil (2002) observed *Obereopsis brevis* and *S. litura* as the key pests of soybean out of 48 phytophagous species observed attacking the crop. Van den berg and Shepard (1998) reported that the natural enemy population increased with increase in host density, although, there was no evidence of density dependence.

Conclusion

Girdle beetle, *O. brevis,* tobacco caterpillar, *S. litura,* green semilooper, *C. acuta,* whiteflies, *B. tabaci* and jassids, *E. kerri* were observed as the major pests on soybean variety JS-335. The peak activity of girdle beetle (1.0 damaged plants/m row) and lepidopterous larvae (3.2 larvae/m row) was recorded during first week of October and second fortnight of August. The sucking pests (6.5 insects/ plant) during second week of August. Among the predators, lady bird beetles, *M. sexmaculata, C. transversalis* and *C. septumpunctata* and spider *Neoscona* sp. were observed preying on whiteflies and jassids; whereas, another spider *Oxyopes* sp. and a predatory pentatomid bug *Eocanthecona furcellata* were observed feeding on the lepidopterous larvae.

Conflict of Interest

The authors have not declared any conflict of interest.

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Scientific Research and Essays

Full Length Research Paper

Comparative performance of some bivoltine silkworm (*Bombyx mori* L.) genotypes during different seasons

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Twenty-six bivoltine silkworm (*Bombyx mori* L.) genotypes were tested along with two check varieties (NB_4D_2 and SH_6) for their performance in respect of 14 metric traits during spring (E_1) and summer (E_2) seasons. No genotype displayed significantly superior performance vis-à-vis check breeds in all the metric traits under study. However, several genotypes registered higher performance in several subsets of traits. The breeds J_2M, A and NCD appear to have potential for commercial exploitation during spring rearing season (E_1), whereas, the breeds CSGRC-5, New Race, JA_1 and Jam $_{21}$ during summer rearing season (E_2). The genotypes Sheiki-II, Pampore-5, J_{122}, Meigitsu, 14M, NJ_3, NB_{18}, CSR_2 and CSR_4 manifested appreciable performance in both spring (E_1) and summer (E_2) season.

Key words: Bivoltine silkworm, performance, metric traits, seasons.

INTRODUCTION

Jammu and Kashmir is the only traditional bivoltine belt in the country, which because of salubrious climatic conditions for silkworm rearing and mulberry cultivation can produce quality bivoltine silk. Lack of productive silkworm breeds/hybrids suited to agro-climatic conditions of J&K state has been identified as one of the major constraints in boosting cocoon production (Trag et al., 1992). Realizing this, some new silkworm breeds were evolved by the Sericulture Division of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir by utilizing the genetic variability of existing germplasm resources (Kamili et al., 2000). Season and region specific studies of silkworm *Bombyx mori* L. are of greater importance in identifying and understanding the adaptability of silkworm genotypes which are largely influenced by climatic factors (Vijayalakshmi et al., 2014). Attempts have been made by several researchers to identify season/region specific breeds throughout the country (Gangwar, 2012, Senapati and Hazarika, 2014, Vijayalakshmi et al., 2014.

Presently, the commercial silkworm rearing in the valley is practiced in spring season only. Extension of rearing to

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other seasons is practically feasible to boost cocoon production and to increase the economic viability of sericulture in the state (Raja et al., 1999). This necessitates the synthesis/identification of breeds/hybrids suited to different rearing seasons. Although, some information about relative performance of a few pure breeds in different seasons has been generated by Malik et al. (1999) and Malik et al. (2005), yet there is no information about performance of other promising genotypes available in the germplasm bank in different seasons. The present experiment was, therefore, undertaken to study the comparative performance of twenty-six vis-a-vis two check breeds of bivoltine silkworm (*Bombyx mori* L.) for their suitability to spring and summer rearing seasons.

MATERIALS AND METHODS

Twenty-eight bivoltine silkworm lines viz., New Race, $Pure_{81}$, Pampore-5, J-122, Meigitsu, JA_1, 14M, SPJ-2, J_2M, B_{38}, CSGRC-5, Belkokona II, Sheiki II, Sannish, A, Jam $_{18}$, Jam $_{21}$, JD_6, YS_3, NJ_3, NCD, NB_{18}, NB_4D_2, CSR_2, CSR_4, SH_6, SRC, JBEL, were obtained from the germplasm banks maintained at Division of Sericulture, SKUAST (K), Mirgund, Division of Sericulture, SKUAST (J), Udhaiwala, Jammu and Central Sericultural Germplasm Resource Centre, Hosur. The genotypes were reared during spring season, April-May, 2007-2009 (E_1). The diapauses of resultant spring seed was broken artificially and reared during summer season, August-September, 2007-2009 (E_2). The experiments were laid out in Completely Randomized Block Designs with three replications for each treatment; each replication comprised 250 worms after 3rd moult. The rearing were conducted following the methods suggested by Dar and Singh (1998). The data pertaining to 14 metric traits viz., Fifth age larval duration, weight of mature larvae, weight of silk gland, single cocoon weight, single shell weight, shell ratio, cocoon yield/10,000 larvae by number and weight., pupation rate, filament length denier raw silk percentage, fecundity and hatching percentage were recorded and subjected to analysis of variance(ANOVA).

RESULTS AND DISCUSSION

The mean performance of 28 bivoltine silkworms is presented in Table 1. No genotype displayed a significant superior performance vis-à-vis check breeds (NB_4D_2 and SH_6) in all the metric traits under study. However, several genotypes registered higher performance in several sub-sets of traits. For example in spring (E_1), CSR_2 displayed a significantly superior performance in 5th age larval duration, single shell ratio, cocoon yield/10,000 larvae by number, pupation rate, filament length, denier and raw silk percentage. CSR_4 in weight of silk gland, single shell ratio, filament length and raw silk percentage. J_2M in 5th age larval duration, filament length, denier and raw silk percentage. Meigitsu in 5th age larval duration, weight of silk gland, denier and raw silk percentage. 14M in 5th age larval duration, weight of silk gland, single shell ratio, filament length and denier. Sheiki II and Pampore-5 in 5th age larval duration, weight of silk gland and denier. A in 5th age larval duration, weight of silk gland, shell ratio and raw silk percentage. NJ_3 in 5th age larval duration, shell ratio and raw silk percentage. NB_{18} in 5th age larval duration, denier and raw silk percentage. Same trend was observed during summer (E_2), wherein, 14M surpassed the check breeds in 5th age larval duration, weight of silk gland, filament length, denier and raw silk percentage. NB_{18} displayed superior performance in 5th age larval duration, cocoon yield/10,000 larvae by number, pupation rate, denier and raw silk percentage. CSGRC-5 in weight of mature larvae, weight of silk gland, filament length and denier. New race in 5th age larval duration, weight of silk gland, denier and raw silk percentage. CSR_2 in 5th age larval duration, weight of silk gland, pupation rate and raw silk percentage. CSR_4 in single cocoon weight, single shell weight, pupation rate and raw silk percentage.

However, judging the performance of genotypes on the basis of individual traits under different seasons becomes slightly difficult, particularly when more than twenty one component traits determine the yielding ability of a silkworm genotype (Thiagarajan et al., 1993). Screening of promising genotypes calls for consideration of cumulative effect of all yield component traits whether acting in positive or negative direction. Inherent genetic barriers like undesirable character associations make the choice still more difficult. Sericulture has several interest groups like seed producers, rearers, reelers and weavers. While traits like fecundity and hatching percentage are important for seed producers, the rearers need breeds with higher cocoon weight, shell weight, survival and low larval duration besides the higher fecundity and hatching percentage. Reelers on the other hand prefer cocoons with high silk contents, longer filament, lesser boil-off loss, less renditta and high neatness. Unfortunately in silkworm fecundity is negatively correlated with robustness and shell ratio. Similarly, length of filament is negatively correlated with reelability. Likewise, weight of cocoons and shell ratio are also negatively correlated. Therefore, it is almost impossible to find a breed with all desirable traits. Therefore, a balance is to be maintained by giving due weightage to important metric traits in deciding the superiority of any particular genotype.

In the present study, the breeds J_2M, A and NCD displayed significantly superior performance in several subsets of traits during spring while, genotypes CSGRC-5, New race, JA_1 and Jam $_{21}$ surpassed the check breeds (NB_4D_2 and SH_6) in a good number of metric traits during summer. The genotypes Sheiki II, Pampore-5, J_{122}, Meigitsu, 14M, NJ_3, NB_{18}, CSR_2 and CSR_4 were significantly superior to the check breeds in several subsets of traits in both spring and summer. This information can be utilized for evolving new season specific breeds with accumulation of maximum desirable traits. Malik et al. (1993) reported that J_{122} and Jam_{21} were potential genotypes for spring rearing in Kashmir.

Table 1. Mean performance of twenty eight genotypes for fourteen metric traits during spring (E_1) and summer (E_2) seasons.

Genotype		5^{th} age larval duration (h)	Weight of mature larvae (g larva^{-10})	Weight of mature silk gland (g)	Single cocoon weight (g)	Single shell weight (g)	Shell ratio (%)	Cocoon yield/ 10,000 larvae by no.	Cocoon yield/ 10,000 larvae by weight (kg)	Pupation rate (%)	Filament length (m)	Denier	Raw silk (%)	Fecundity	Hatching (%)
SPJ_2	E_1	*173.16	42.43	1.18	1.99	0.36	18.39	7542	15.03	82.65	714	3.59	*14.38	536	88.08
	E_2	*174.36	26.95	0.96	1.28	0.21	16.36	6464	8.29	63.86	630	2.18	12.51	486	85.58
J_2M	E_1	*167.20	44.53	1.54	2.20	0.39	17.93	7462	16.41	84.62	●1033	*2.49	*14.96	537	92.90
	E_2	176.26	31.54	0.93	1.38	0.22	15.86	5151	7.14	47.71	●736	2.28	●14.52	487	90.40
B_{38}	E_1	*165.28	41.16	*1.99	1.76	0.30	17.04	6872	12.09	85.62	883	2.78	12.04	608	93.98
	E_2	*170.28	31.46	0.97	1.10	0.18	16.93	5959	6.57	63.86	586	2.17	10.64	558	91.48
CSGRC-5	E_1	173.51	49.33	1.43	2.01	0.38	●19.23	8641	17.37	86.21	948	2.7	*14.68	525	95.59
	E_2	177.20	●36.30	●1.06	1.54	0.27	17.49	6363	9.81	69.59	●925	*1.99	12.56	475	92.89
Belkokona II	E_1	*164.31	39.23	1.48	1.55	0.27	17.85	7341	11.37	84.18	693	2.71	12.53	571	94.89
	E_2	177.38	25.54	0.99	1.15	0.17	14.78	4747	5.45	53.71	500	*2.03	10.77	521	92.39
Sheiki II	E_1	*156.61	48.66	*1.84	1.99	0.31	15.86	8272	16.51	83.21	676	*2.64	11.24	603	90.07
	E_2	*166.05	●36.83	0.96	1.51	0.23	15.16	7777	11.79	●82.71	697	2.22	11.79	553	87.57
Sannish	E_1	*169.41	44.63	1.45	1.81	0.33	18.23	8584	15.54	82.94	821	3.08	12.76	552	90.57
	E_2	177.38	20.96	0.80	●1.70	0.21	12.50	76761	13.10	64.54	740	2.55	11.39	502	88.07
New race	E_1	*158.21	44.46	1.42	1.94	0.32	16.66	7858	15.24	82.14	841	2.77	12.42	643	85.20
	E_2	*170.25	27.63	●1.07	1.39	0.22	15.83	4141	5.75	41.64	826	*2.10	●14.70	493	82.70
Pure 81	E_1	173.72	39.73	1.26	2.02	0.33	16.61	7732	15.67	84.68	807	*2.49	13.01	577	89.31
	E_2	175.21	34.46	0.91	1.56	0.25	16.24	6160	9.61	73.16	742	2.46	11.62	527	86.81
Pampore-5	E_1	*150.95	45.56	*1.68	1.83	0.32	17.82	8849	16.22	86.18	791	*2.58	12.55	565	94.33
	E_2	*169.35	26.53	0.93	1.13	0.18	15.83	5959	6.77	57.41	644	*2.01	●13.27	515	91.83
J_{122}	E_1	*162.23	45.20	1.48	1.58	0.33	●20.82	8952	14.19	*87.60	670	2.83	11.99	612	98.02
	E_2	*171.41	32.70	0.93	1.39	0.21	15.34	●8585	11.93	●88.79	685	2.27	12.22	562	95.52
Meigitsu	E_1	*155.30	47.53	*1.77	1.98	0.36	18.28	9030	17.94	86.22	893	*2.43	*14.37	609	94.80
	E_2	*168.20	28.93	●1.13	1.45	0.21	14.90	7070	10.27	70.59	768	*1.95	12.61	559	92.30
JA_1	E_1	*171.18	39.63	1.34	1.78	0.34	●19.40	8040	14.36	86.36	584	3.02	10.72	507	97.06
	E_2	*170.40	28.80	●1.06	.38	0.21	15.21	8383	11.56	●84.07	602	2.44	12.23	457	94.56
14M	E_1	*166.28	44.30	*1.96	1.92	0.36	●18.68	8727	16.81	83.95	●1189	*2.62	13.82	533	90.87
	E_2	*172.61	30.78	●1.06	1.33	0.20	15.46	6261	8.37	60.50	●868	*2.00	●13.79	483	88.37
A	E_1	*163.21	44.93	*1.78	1.67	0.34	●20.27	8265	13.85	83.29	869	2.96	*15.45	555	88.42
	E_2	*173.30	31.39	0.97	1.17	0.23	19.54	7301	8.59	73.29	769	2.26	●13.48	505	85.92
Jam 18	E_1	173.32	46.46	1.53	1.93	0.36	●18.96	8625	16.67	83.62	552	3.09	12.25	474	88.91
	E_2	*172.96	30.53	0.81	1.43	0.26	18.14	7647	10.96	73.71	562	2.55	11.13	424	86.41
Jam_{21}	E_1	173.34	42.43	1.28	2.01	0.31	15.42	8631	17.48	84.07	822	3.20	12.57	579	95.32
	E_2	175.35	34.86	●1.11	●1.58	0.25	15.82	7201	11.37	78.01	703	*2.07	12.72	529	92.82
JD_6	E_1	173.54	37.36	0.98	1.81	0.29	16.02	8731	15.80	84.91	708	2.72	13.95	551	95.84
	E_2	*169.68	35.76	0.99	1.42	0.22	15.69	7647	10.88	67.58	755	*2.12	13.01	499	93.34
YS_3	E_1	*162.50	43.06	1.40	1.78	0.28	15.85	9055	16.17	85.22	849	*2.31	12.60	545	96.20
	E_2	*172.84	23.63	0.99	1.14	0.16	14.32	4630	5.27	47.71	621	*2.05	13.02	495	93.70
NJ_3	E_1	*166.40	41.76	●1.25	1.65	0.30	●18.54	8860	14.65	83.96	627	3.32	*14.38	580	90.05
	E_2	*170.10	25.80	●1.06	1.20	0.20	16.89	7148	8.60	75.31	566	2.44	●13.64	530	87.55
NCD	E_1	*165.16	42.43	1.33	1.65	0.33	●20.20	9079	14.98	82.57	820	2.87	*15.39	504	89.44
	E_2	176.56	26.60	0.80	1.16	0.18	15.80	5767	6.69	60.50	585	2.15	12.76	454	86.94
NB_{18}	E_1	*171.32	42.93	1.23	1.90	0.35	18.38	●9151	17.41	●86.77	855	*2.61	*5.50	551	97.28
	E_2	*173.69	31.90	1.00	1.38	0.23	16.66	●8615	11.89	●90.80	793	*2.03	●13.70	497	94.78
CSR_2	E_1	*170.36	45.10	●1.47	1.88	0.41	●21.98	*9639	18.12	*87.39	●1146	*2.64	*14.39	639	93.51

Table 1. Contd

	E_2	*174.56	31.76	●1.10	1.35	0.25	18.51	7593	11.25	●81.37	834	2.18	●14.69	589	91.01
CSR_4	E_1	173.55	45.63	*1.76	1.97	0.40	●20.30	9338	18.39	86.21	●1068	2.87	*16.56	652	95.57
	E_2	177.18	25.53	0.90	●1.66	*0.29	17.46	6757	11.21	●80.19	748	2.37	●14.38	600	93.07
SRC	E_1	*159.27	41.96	1.35	1.72	0.29	16.98	8019	13.84	83.75	838	3.11	*16.77	579	94.79
	E_2	*169.10	22.66	0.83	1.55	0.26	17.13	4342	6.76	39.28	575	2.63	11.86	529	91.96
JBEL	E_1	177.35	44.63	1.39	1.81	0.32	17.68	8338	15.09	83.97	893	*2.27	12.68	559	95.64
	E_2	179.66	31.36	0.96	1.25	0.19	15.19	7954	10.94	70.02	655	*2.03	11.37	500	92.80
Check breeds															
NB_4D_2	E_1	171.26	52.26	1.14	2.27	0.40	17.59	8866	20.15	85.88	932	3.02	12.50	559	96.42
	E_2	174.33	34.43	1.00	1.56	0.25	16.24	8389	13.08	78.68	789	2.32	12.29	509	93.59
SH_6	E_1	173.88	49.43	1.52	2.19	0.37	17.04	9149	20.03	86.29	870	2.68	13.42	609	97.65
	E_2	175.01	32.43	0.93	1.41	0.26	18.67	7253	10.22	74.95	629	2.18	11.91	559	95.15
CD (0.05)	E_1	0.564	0.769	0.020	0.016	0.014	0.844	61.698	0.156	0.841	64.713	0.035	0.694	51.910	1.444
	E_2	0.424	0.748	0.013	0.012	0.015	1.064	55.319	0.122	1.272	56.308	0.038	0.728	57.01	1.568

Key: *Superior to SH_6; ● Superior to NB_4D_2.

Malik et al. (2005) reported that genotypes Jam_{21} and CSR_4 hold promise for commercial exploitation during both spring and summer seasons. These results are in general agreement with (Gangwar, 2012, Senapati and Hazarika, 2014, Vijayalakshmi et al., 2014.

Conclusion

The breeds J_2M, A and NCD displayed significantly superior performance in several subsets of traits while, genotypes CSGRC-5, New race, JA_1 and Jam $_{21}$ surpassed the check breeds (NB_4D_2 and SH_6) in a good number of metric traits during summer. The genotypes Sheiki II, Pampore-5, J_{122}, Meigitsu, 14M, NJ_3, NB_{18}, CSR_2 and CSR_4 were significantly superior to the check breeds in several subsets of traits in both spring and summer. These genotypes can further be tested over seasons/years to confirm the stability of their performance. Moreover, this information can be utilized for evolving new season specific breeds with accumulation of maximum desirable traits.

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Scientific Research and Essays

Full Length Research Paper

Performance of summer sesame (*Sesamum indicum* L.) cultivars under varying dates of sowing in prevailing agro-climatic condition of North Bengal

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To study the effect of dates of sowing and improved cultivars on growth and yield of summer sesame in North Bengal five different dates of sowing (10th February, 20th February, 2nd March, 12th March and 22nd March and three cultivars of sesame (Rama, Savitri and Tillotama) with three replications. The highest (114.66 and 115.83 cm) plant height was recorded when sesame sown on 12th March (D_4) and which was statistically at par with 2nd March (D_3). Among the varying date of sowing, the highest dry matter accumulation, leaf area index and crop growth rate was recorded in 2nd day of March compared to the other date of sowing. Among the improved cultivars of sesame, the variety Rama recorded higher plant height, dry matter accumulation, leaf area index and crop growth rate compared to Savitri and Tillotoma. The highest yield was recorded when sesame sown on 2nd March which was 55.99 and 40.85% higher than the crops sown on 22nd March during 2013 and 2014 respectively. Rama also exhibited highest seed yield recording 17.70 and 12.06% higher than the cultivars Tillotama and Savitri. The date of sowing significantly influenced the yield attributes and highest yield attributes was recorded when sesame sown on 2nd March. Improved cultivar, Rama recorded the highest yield attributing characters compared to the Savitri and Tillotoma. It can be concluded that sowing of sesame within 2nd March to 12th March is the optimum sowing dates of sesame to have optimum seed yield if grown as late summer crop. Result indicated that cultivar Rama can be adopted in *terai* zone of West Bengal during summer season, because of its highest seed yield ability.

Key words: Sesame, cultivars, date of sowing, growth, yield, yield attributes.

INTRODUCTION

Sesame (*Sesamum indicum* L.), the queen of vegetable oils belonging to family Pedaliaceae is one of the oldest oil-rich plants in the world (Janick and Whipkey, 2002) and that originated in Africa (Brar and Ahuja, 1979; Ram et al., 1990). It is widely grown in tropical and subtropical regions. Its production is often concentrated in marginal and sub marginal lands (Ashri, 1998). India ranks among the top six world producers of sesame seed. Thus, production growth and quality improvement of oilseeds can substantially contribute to the economic development at national, regional and at family level. It is a non-leguminous annual flowering green plant cultivated

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primarily for its small edible seeds rich in oil and protein of about 50 and 25% respectively (Langham et al., 2006). There are also intermediate coloured varieties varying from red to rose or from brown or grey.

The low yields coupled with problems encountered during harvesting sesame have tended to discourage growers, leading to a decline in the total area devoted to its cultivation. In general, the production constraints include poor agronomic practice, pest and disease, weed infestation, poor soil fertility, low yielding cultivars. However, crop improvement in sesame has been practiced for a long time. Yet a major breakthrough could not be made in realizing high yields in sesame varieties. One of the reasons is that there is limited genetic variability in the source material. It is a seasonal and location bound crop hence, a particular variety does not perform uniformly in all locations and in all seasons. The yielding ability of sesame crop is determined by many yield components, all of which are substantially influenced by environmental conditions and agronomic packages. The grain yield of sesame is significantly influenced by sowing date and cultivars (Hazarika, 1998). Moreover, temperature and variety affected seed yield variation by 69 and 39%, respectively (Sharma, 2005). The effect of photoperiodism on sesame has been thoroughly studied, since this is a major factor influencing seed yield. According to El-Bakheit (1985) delaying of sesame sowing increased the incidence of pests and diseases. Therefore, for successful production of crop most optimum sowing time and cultivars are indispensable (Ali et al., 2005).

In this region sesame is cultivated as a rainfed crop during pre- kharif and kharif season but it is also grown during summer season in residual soil moisture under poor management practices. Hence, the yield of sesame in this region is generally low due to use of low yielding cultivars (local) with poor agronomic management practices. Research works are limited on sowing time and cultivars under *terai* agro-climatic situation of West Bengal. Hence, here is a need of research effort is to be under taken to identify the sesame cultivars with desirable character. Considering the above mentioned reason, a study on growth and yield improved sesame cultivars under varying date of sowing was carried out under this region.

MATERIALS AND METHODS

A field experiment was conducted at the Instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India during 2013 to 2014 to study the effect of dates of sowing and improved cultivars on growth and yield of summer sesame (*Sesamum indicum* L.). The treatment consisted of five different dates of sowing that is, 10th February, 20th February, 2nd March, 12th March and 22nd March (symbolized as D_1, D_2, D_3, D_4 and D_5, respectively) in the main plots and three cultivars that is, Rama, Savitri and Tillotama (symbolized as V_1, V_2 and V_3, respectively) in the sub plot, in a split plot design with three replication. The farm is situated at 26°19′86″ N latitude and 89°23′53″ E longitude and at an elevation of 43 m above mean sea level. The soil of the experimental field was sandy loam in texture with pH 5.7. The results were analyzed taking consideration of pre harvest parameters like plant height (cm), dry matter accumulation (DMA), Leaf area index (LAI) calculated according to the formula given by Watson (1947).

$$\text{Leaf area index (LAI)} = \frac{\text{Area of total number of leaves surface}}{\text{Ground area from which leaf sample were collected}}$$

Then the mean LAI (L) was calculated as per the formula given below.

$$\textbf{Mean LAI } (\bar{L}) = \frac{L_2 - L_1}{\text{Log}_e L_2 - \text{Log}_e L_1}$$

Where, L_1 and L_2 are the leaf area indices at two successive occasions on time t_1 and t_2 respectively.

Crop growth rate (CGR) expresses the gain in dry matter production of the crop per unit land area per unit time and is expressed as gram per meter square per day (g m^{-2} day^{-1}). It is calculated according to the formula given by Watson (1952).

$$CGR = \frac{W_2 - W_1}{t_2 - t_1}$$

Where, $W_1$and W_2 were the dry weight of the aerial plants per unit area gained at time t_1 and t_2 respectively. Postharvest parameters like number of branches $plant^{-1}$, number of capsules $plant^{-1}$, number of seed $capsule^{-1}$ and test weight of seed [1000 seed weight (g)], seed yield (t ha^{-1}), stem yield (t ha^{-1}) and harvest index (%). Data were analyzed by using INDO-STAT- software for analysis of variance following split- plot design treatment means were separated by applying critical difference (CD) test at 5% level of significance.

RESULTS AND DISCUSSION

Effect of date of sowing and improved cultivars on growth attributing characters of sesame

Effect of treatments on growth

Irrespective of date of sowing and improved cultivars of sesame, plant height kept on increasing till the last observation recorded at harvest. The plant height increased with the advancement of the crop age due to its growth and reached its maximum at harvest irrespective of the treatments tried (Table 1). LAI was low at the early stages of crop growth (Table 2) and kept on increasing with advancement of crop age up to 75 DAS when reached at its peak. Thereafter it decline towards maturity of the crop touches which was stopped at the reproductive stages of the crop. Another reason may be attributed to senescence of the leaves at the later stage of crop growth. Dry matter accumulation was lowest at 30 DAS thereafter rapid accumulation of dry matter was noticed till at harvest. The rate of accumulation became slower and it reaches at its maximum value till the last

Table 1. Effect of dates of sowing and improved cultivars on plant height (cm) of sesame.

Treatment	Plant height (cm)											
	Days after sowing											
	30			60			75			At harvest		
	YI	YII	Pooled	YI	YII	Pooled	YI	YII	Pooled	YI	YII	Pooled
D_1	6.81	4.83	5.82	31.92	23.07	27.49	61.77	56.88	59.33	99.77	91.00	95.38
D_2	8.47	8.47	8.47	44.22	35.22	39.72	74.85	65.77	70.31	107.11	102.16	104.64
D_3	13.00	11.38	12.19	63.16	62.66	62.91	95.66	87.33	91.50	112.11	114.66	113.38
D_4	13.41	12.72	13.07	66.00	69.33	67.66	96.77	92.44	94.61	114.66	115.83	115.25
D_5	12.39	9.47	10.93	62.12	48.88	55.50	92.87	78.22	85.54	109.55	112.83	111.19
S. Em. (±)	**0.44**	**0.54**	**0.39**	**2.89**	**1.78**	**1.66**	**3.44**	**4.64**	**3.03**	**3.76**	**4.50**	**2.02**
C.D. (0.05)	**1.43**	**1.78**	**1.29**	**9.44**	**5.80**	**5.43**	**11.22**	**15.13**	**9.90**	**12.27**	**14.70**	**6.59**
V_1	11.26	9.82	10.54	56.03	49.35	52.69	86.44	78.60	82.52	112.53	108.68	110.61
V_2	10.86	9.26	10.06	54.43	47.68	51.06	84.28	75.46	79.87	108.13	107.23	107.68
V_3	10.34	9.05	9.69	49.99	46.46	48.23	82.43	74.33	78.38	105.26	105.97	105.62
S. Em. (±)	**0.16**	**0.24**	**0.15**	**2.12**	**0.99**	**1.14**	**1.85**	**1.83**	**1.11**	**1.22**	**2.58**	**1.20**
C.D. (0.05)	**0.49**	**NS**	**0.45**	**NS**	**NS**	**3.36**	**NS**	**NS**	**3.29**	**3.62**	**NS**	**3.56**
D_1V_1	7.26	5.01	6.14	35.33	23.26	29.30	65.83	60.66	63.25	106.00	92.00	99.00
D_1V_2	6.93	4.76	5.85	31.83	23.11	27.47	60.66	55.66	58.16	98.66	91.00	94.83
D_1V_3	6.23	4.73	5.48	28.60	22.83	25.72	58.83	54.33	56.58	94.66	90.00	92.33
D_2V_1	9.03	8.83	8.93	45.66	37.16	41.41	76.33	69.33	72.83	110.00	103.61	106.80
D_2V_2	8.50	8.50	8.50	44.33	35.00	39.66	75.22	64.66	69.94	107.00	102.66	104.83
D_2V_3	7.90	8.10	8.00	42.66	33.50	38.08	73.00	63.33	68.16	104.33	100.22	102.28
D_3V_1	13.50	11.83	12.66	65.50	63.83	64.66	96.55	88.00	92.27	115.33	116.33	115.83
D_3V_2	13.00	11.33	12.16	65.33	62.66	64.00	95.77	87.33	91.55	111.66	114.33	113.00
D_3V_3	12.50	11.00	11.75	58.66	61.50	60.08	94.66	86.66	90.66	109.33	113.33	111.33
D_4V_1	13.56	13.66	13.61	68.66	72.33	70.50	98.50	95.66	97.08	119.33	117.33	118.33
D_4V_2	13.26	12.33	12.80	67.33	68.00	67.66	96.33	91.00	93.66	114.33	115.16	114.75
D_4V_3	13.41	12.16	12.79	62.00	67.66	64.83	95.50	90.66	93.08	110.33	115.00	112.66
D_5V_1	12.93	9.76	11.35	65.00	50.16	57.58	95.00	79.33	87.16	112.00	114.16	113.08
D_5V_2	12.60	9.27	10.98	63.33	49.66	56.50	93.44	78.66	86.05	109.00	113.00	111.00
D_5V_3	11.65	9.37	10.46	58.04	46.83	52.43	90.16	76.66	83.41	107.66	111.33	109.50
	D X V / V X D	**D X V / V X D**	**D X V / V X D**	**D X V / V X D**	**D X V / V X D**	**D X V / V X D**	**D X V / V X D**	**D X V / V X D**	**D X V / V X D**	**D X V / V X D**	**D X V / V X D**	**D X V / V X D**
S. Em. (±)	**0.37 / 0.53**	**0.55 / 0.71**	**1.24 / 1.17**	**4.75 / 4.84**	**2.21 / 2.53**	**2.55 / 2.66**	**4.14 / 4.82**	**4.09 / 5.72**	**2.49 / 3.65**	**2.74 / 4.38**	**5.78 / 6.53**	**2.70 / 2.99**
C.D. (0.05)	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**

YI= 2013 & YII=2014; DI=10th February, D2=20th February, D3=2nd March, D4=12th March, D5=22nd March and V1= Rama, V2= Savitri & V3= Tillotama.

observation at harvest increased at an increasing rate up to harvest and thereafter it increased with decreasing rate, irrespective of date of sowing and improved cultivars. This indicate that the initial growth rate (Table 3). The rate of dry matter accumulationas measured by the dry matter accumulation was packed up as the crop passes through the seed filling and maturity stage. Crop growth rate was low at the early stages of crop

Table 2. Effect of dates of sowing and improved cultivars on leaf area index of sesame.

Treatment	Leaf area index											
	Days after sowing											
	30			60			75			At harvest		
	YI	YII	Pooled	YI	YII	Pooled	YI	YII	Pooled	YI	YII	Pooled
D_1	0.14	0.15	0.15	1.14	0.83	0.98	1.61	1.23	1.42	0.61	0.55	0.58
D_2	0.29	0.20	0.24	1.40	1.05	1.22	1.83	1.43	1.63	0.75	0.61	0.68
D_3	0.33	0.30	0.31	1.71	1.44	1.57	2.20	1.82	2.01	0.93	0.97	0.95
D_4	0.30	0.29	0.29	1.45	1.22	1.33	2.12	1.72	1.92	0.84	0.81	0.82
D_5	0.24	0.29	0.26	1.20	0.90	1.05	1.72	1.38	1.55	0.69	0.68	0.68
S. Em. (±)	**0.01**	**0.01**	**0.007**	**0.03**	**0.05**	**0.03**	**0.04**	**0.04**	**0.03**	**0.04**	**0.03**	**0.03**
C.D. (0.05)	**0.03**	**0.04**	**0.02**	**0.11**	**0.18**	**0.09**	**0.13**	**0.14**	**0.11**	**0.15**	**0.12**	**0.09**
V_1	0.28	0.26	0.27	1.51	1.16	1.33	1.98	1.59	1.78	0.80	0.78	0.79
V_2	0.25	0.24	0.25	1.36	1.08	1.22	1.89	1.50	1.70	0.76	0.71	0.74
V_3	0.24	0.23	0.24	1.27	1.02	1.15	1.82	1.45	1.63	0.73	0.67	0.70
S. Em. (±)	**0.004**	**0.01**	**0.006**	**0.03**	**0.03**	**0.02**	**0.04**	**0.03**	**0.03**	**0.02**	**0.01**	**0.01**
C.D. (0.05)	**0.01**	**0.02**	**0.01**	**NS**	**0.09**	**0.07**	**NS**	**0.12**	**0.11**	**0.06**	**0.04**	**0.05**
D_1V_1	0.15	0.19	0.16	1.32	0.86	1.09	1.69	1.27	1.48	0.64	0.58	0.61
D_1V_2	0.15	0.14	0.14	1.13	0.83	0.98	1.60	1.23	1.41	0.62	0.56	0.59
D_1V_3	0.14	0.13	0.14	0.97	0.78	0.88	1.53	1.18	1.35	0.58	0.51	0.54
D_2V_1	0.30	0.20	0.25	1.50	1.14	1.32	1.93	1.50	1.72	0.78	0.67	0.73
D_2V_2	0.28	0.20	0.24	1.36	1.01	1.19	1.79	1.42	1.60	0.07	0.60	0.68
D_2V_3	0.27	0.19	0.23	1.34	0.98	1.16	1.76	1.37	1.56	0.72	0.56	0.64
D_3V_1	0.38	0.32	0.35	1.76	1.53	1.64	2.28	1.92	2.10	1.01	1.00	1.00
D_3V_2	0.31	0.30	0.30	1.72	1.40	1.56	2.22	1.80	2.01	0.91	0.97	0.94
D_3V_3	0.30	0.27	0.28	1.65	1.39	1.52	2.11	1.76	1.93	0.87	0.94	0.90
D_4V_1	0.30	0.31	0.30	1.56	1.30	1.43	2.21	1.83	2.02	0.88	0.93	0.90
D_4V_2	0.28	0.28	0.28	1.43	1.24	1.33	2.12	1.70	1.91	0.83	0.77	0.80
D_4V_3	0.29	0.28	0.28	1.36	1.13	1.24	2.05	1.62	1.83	0.80	0.74	0.77
D_5V_1	0.27	0.30	0.29	1.42	0.96	1.19	1.79	1.41	1.60	0.70	0.73	0.72
D_5V_2	0.22	0.29	0.26	1.16	0.89	1.03	1.72	1.38	1.55	0.68	0.66	0.67
D_5V_3	0.21	0.28	0.25	1.03	0.82	0.93	1.66	1.32	1.49	0.66	0.63	0.65

	30 YI		30 YII		30 Pooled		60 YI		60 YII		60 Pooled		75 YI		75 YII		75 Pooled		At harvest YI		At harvest YII		At harvest Pooled	
	D X V	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**
S. Em. (±)	**0.01**	**0.01**	**0.02**	**0.02**	**0.01**	**0.01**	**0.07**	**0.06**	**0.07**	**0.08**	**0.05**	**0.05**	**0.09**	**0.28**	**0.08**	**0.08**	**0.08**	**0.07**	**0.05**	**0.06**	**0.03**	**0.04**	**0.03**	**0.04**
C.D. (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

YI= 2013 & YII=2014; DI=10th February, D2=20th February, D3=2nd March, D4=12th March, D5=22nd March and V1= Rama, V2= Savitri & V3= Tillotama.

growth (Table 4) and kept on increasing with advancement of crop slow at vegetative stages of crop growth which age up to 60-75 DAS when reached at its peak and after it decline towards maturity of the crop.

Date of sowing was significantly influenced height of the plant at all stages of crop growth upto harvest (Table 1). Among the date of sowing, the highest (114.66 and 115.83) plant height at

Table 3. Effect of dates of sowing and improved cultivars on dry matter accumulation of sesame.

Treatment	Dry matter accumulation (g m^{-2}) Days after sowing 30 YI	30 YII	30 Pooled	60 YI	60 YII	60 Pooled	75 YI	75 YII	75 Pooled	At harvest YI	At harvest YII	At harvest Pooled
D_1	15.79	12.90	14.35	180.00	176.73	178.36	386.44	381.20	383.82	539.66	499.22	516.84
D_2	17.12	14.83	15.98	195.00	193.70	194.35	422.22	387.74	404.98	581.77	536.33	556.95
D_3	18.55	18.34	18.45	225.11	217.18	221.14	488.00	471.84	479.92	696.33	660.88	676.33
D_4	17.04	16.48	16.76	206.22	200.31	203.26	455.77	411.36	433.56	629.77	561.11	592.33
D_5	16.05	16.07	16.06	189.88	174.00	181.94	404.11	379.33	391.72	542.55	496.55	519.56
S. Em. (+)	**0.52**	**1.13**	**0.66**	**8.03**	**8.41**	**5.62**	**6.10**	**13.46**	**8.27**	**6.99**	**14.01**	**9.18**
C.D. (0.05)	**1.70**	**3.69**	**2.16**	**26.19**	**27.45**	**18.33**	**19.91**	**43.90**	**26.97**	**22.81**	**45.70**	**29.95**
V_1	17.57	17.03	17.30	210.30	204.03	207.17	454.26	429.54	441.90	634.00	589.73	607.91
V_2	16.99	15.72	16.36	197.89	192.05	194.97	428.73	407.28	418.00	593.33	551.06	571.30
V_3	16.17	14.42	15.29	189.53	181.07	185.30	410.93	382.05	396.49	566.73	511.66	538.00
S. Em. (+)	**0.27**	**0.47**	**0.29**	**3.15**	**7.69**	**4.37**	**6.85**	**8.12**	**5.53**	**6.33**	**9.29**	**6.05**
C.D. (0.05)	**0.82**	**1.40**	**0.87**	**9.31**	**NS**	**12.89**	**20.22**	**23.95**	**16.31**	**18.68**	**27.43**	**17.86**
D_1V_1	16.10	14.50	15.30	188.33	184.33	186.33	405.66	394.76	400.21	571.33	521.66	540.33
D_1V_2	15.71	12.45	14.08	181.33	177.33	179.33	388.00	384.77	386.38	538.00	505.00	519.84
D_1V_3	15.57	11.75	13.66	170.33	168.53	169.43	365.66	364.06	364.86	509.66	471.00	490.33
D_2V_1	17.52	15.3	16.45	206.66	206.37	206.52	444.33	417.66	431.00	622.00	580.33	594.84
D_2V_2	17.40	13.80	15.60	192.66	193.82	193.24	419.33	390.19	404.76	573.33	538.66	556.00
D_2V_3	16.46	15.30	15.88	185.66	180.92	183.29	403.00	355.36	379.18	550.00	490.00	520.00
D_3V_1	19.08	22.21	20.65	237.66	231.03	234.34	514.0	498.20	506.10	736.33	709.00	720.50
D_3V_2	18.86	19.52	19.19	224.33	213.66	219.00	481.66	471.42	476.54	685.33	659.66	672.33
D_3V_3	17.71	13.30	15.51	213.33	206.88	210.10	468.33	445.90	457.11	667.33	614.00	636.16
D_4V_1	18.36	16.73	17.55	220.66	210.66	215.66	480.00	440.10	460.05	670.00	608.33	634.00
D_4V_2	16.94	16.58	16.76	200.33	205.09	202.71	448.00	415.68	431.84	618.66	562.66	588.00
D_4V_3	15.80	16.13	15.97	197.66	185.17	191.42	439.33	378.30	408.81	600.66	512.33	555.00
D_5V_1	16.80	16.32	16.56	198.20	187.80	193.00	427.33	397.00	412.16	570.33	529.33	549.84
D_5V_2	16.06	16.27	16.17	190.80	170.33	180.56	406.66	374.33	390.50	551.33	489.33	520.33
D_5V_3	15.28	15.63	15.46	180.66	163.86	172.26	378.33	366.66	372.50	506.00	471.00	488.50

Treatment	30 YI D X V	30 YI V X D	30 YII D X V	30 YII V X D	30 Pooled D X V	30 Pooled V X D	60 YI D X V	60 YI V X D	60 YII D X V	60 YII V X D	60 Pooled D X V	60 Pooled V X D	75 YI D X V	75 YI V X D	75 YII D X V	75 YII V X D	75 Pooled D X V	75 Pooled V X D	At harvest YI D X V	At harvest YI V X D	At harvest YII D X V	At harvest YII V X D	At harvest Pooled D X V	At harvest Pooled V X D
S. Em. (+)	**0.62**	**2.59**	**1.06**	**1.42**	**0.65**	**0.85**	**7.06**	**9.88**	**17.2**	**16.4**	**9.77**	**9.76**	**15.3**	**13.9**	**18.2**	**20.3**	**12.4**	**13.05**	**14.2**	**13.5**	**20.9**	**22.1**	**13.5**	**14.6**
C.D. (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

YI= 2013 & YII=2014; DI=10th February, D2=20th February, D3=2nd March, D4=12th March, D5=22nd March and V1= Rama, V2= Savitri & V3= Tillotama.

harvest was recorded in sowing of sesame on 12th March (D_4) and which was statistically at par with 2nd March (D_3). Peter and Yakubu (2012) reported that plant heights significantly influenced due to sowing were delayed. Sowing of sesame on 2nd day of March (D_3) recorded significantly higher leaf area index (2.20 and 1.82) as compared to other dates of sowing and sesame sown on 10th February (D_1) gave the lowest leaf area index

Table 4. Effect of dates of sowing and improved cultivars on crop growth rate of sesame.

Treatment	Crop growth rate (g m^{-2} day^{-1})								
	Days after sowing								
	45-60			60-75			75-90		
	YI	YII	Pooled	YI	YII	Pooled	YI	YII	Pooled
D_1	9.75	9.61	9.68	13.76	13.63	13.69	5.72	4.63	5.17
D_2	10.27	10.46	10.36	15.14	12.93	14.02	6.09	5.93	6.01
D_3	11.72	11.28	11.50	17.52	16.97	17.25	8.37	7.56	7.97
D_4	10.97	10.59	10.78	16.63	14.07	15.35	6.74	5.67	6.20
D_5	10.11	9.04	9.58	14.28	13.68	13.98	5.88	4.91	5.40
S. Em. (±)	**0.50**	**0 .62**	**0.38**	**0.67**	**0.93**	**0.58**	**0.37**	**0.34**	**0.20**
C.D. (0.05)	**1.65**	**2.02**	**1.24**	**2.19**	**3.05**	**1.91**	**1.21**	**1.13**	**0.67**
V_1	11.08	10.79	10.93	16.26	15.03	15.64	6.94	6.48	6.71
V_2	10.50	10.16	10.33	15.38	14.34	14.86	6.48	5.68	6.08
V_3	10.12	9.64	9.88	14.76	13.39	14.07	6.26	5.06	5.66
S. Em. (±)	**0.21**	**0.52**	**0.31**	**0.48**	**0.57**	**0.41**	**0.26**	**0.34**	**0.23**
C.D. (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**1.22**	**NS**	**NS**	**NS**
D_1V_1	10.04	10.01	10.03	14.48	14.02	14.25	5.86	5.22	5.54
D_1V_2	9.81	9.65	9.73	13.78	13.82	13.80	5.68	4.84	5.26
D_1V_3	9.41	9.31	9.29	13.02	13.03	13.02	5.62	3.82	4.72
D_2V_1	10.91	11.06	10.99	15.84	14.08	14.96	6.55	6.40	6.47
D_2V_2	10.15	10.46	10.30	15.11	13.09	14.10	6.04	5.87	5.96
D_2V_3	9.75	9.84	9.80	14.49	11.62	13.05	5.69	5.53	5.61
D_3V_1	12.22	11.89	12.06	18.42	17.81	18.11	8.95	8.58	8.77
D_3V_2	11.75	11.04	11.40	17.15	17.18	17.17	8.20	7.46	7.83
D_3V_3	11.20	10.89	11.04	17.00	15.93	16.46	7.97	6.65	7.31
D_4V_1	11.70	11.11	11.40	17.28	15.29	16.29	7.31	6.34	6.83
D_4V_2	10.63	10.88	10.76	16.51	14.03	15.27	6.64	5.48	6.06
D_4V_3	10.60	9.78	10.19	16.11	12.87	14.49	6.26	5.18	5.72
D_5V_1	10.52	9.87	10.19	15.27	13.94	14.61	6.02	5.86	5.94
D_5V_2	10.18	8.76	9.47	14.39	13.60	13.99	5.86	4.75	5.31
D_5V_3	9.64	8.48	9.06	13.18	13.52	13.34	5.75	4.13	4.94

Treatment	45-60 YI		45-60 YII		45-60 Pooled		60-75 YI		60-75 YII		60-75 Pooled		75-90 YI		75-90 YII		75-90 Pooled	
	D X V	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**
S. Em. (±)	**0.47**	**0.63**	**1.17**	**1.14**	**0.69**	**0.68**	**1.08**	**1.10**	**1.29**	**1.40**	**0.93**	**0.95**	**0.59**	**0.61**	**0.77**	**0.71**	**0.52**	**0.47**
C.D. (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

YI= 2013 & YII=2014; DI=10th February, D2=20th February, D3=2nd March, D4=12th March, D5=22nd March and V1= Rama, V2= Savitri & V3= Tillotama.

(1.61 and 1.23 during both the years of experimentation respectively) at 75 DAS (2). Dry matter production was found to increase starting from 30 DAS onwards and continued up-to harvest with all the date of sowing. The highest (696.33 and 660.88) amount of dry matter accumulation was recorded from when sesame shown on 2nd March (D_3) (Table 3). The better sink capacity might be attributed to the better dry matter production owing to better photosynthetic capacity of plant during reproductive phase of crop. The present results are in conformity with earlier findings of Pawar (1991) and Kanabur (1998).

The crop growth rate was found to be notably significant due to the effect of dates of sowing during both years of experimentation respectively. The highest (17.52 and 16.97) crop growth rate was recorded when sesame shown on 2nd day of March (D_3) and lowest crop growth rate (13.76 and 13.63) was recorded when crop shown on 10th February (D_1) between 60-75 DAS during both the years of experimentation respectively (Table 4).

Plant height was significantly influenced by the improved sesame cultivars at 30, 90 and at harvest in first year of experimentation (Table 1). Among the cultivars, Rama recorded highest (112.53 and 108.68 at harvest) plant height followed by Savitri and Tillotoma at all stages of crop growth. This might be due to genetic makeup and climatic condition which enhanced the growth and development of sesame. Among the improved cultivars highest (1.98 and 1.59) leaf area index was recorded in cultivars Rama followed by Savitri and Tillotoma at all stages crop growth (Table 2). This might be due to absorption and utilization of moisture, nutrients and light by crop which significantly influenced the leaf area. Similar observation was made by Pawar (1991). The highest (634.00 and 589.73) dry matter accumulation was recorded in cultivars Rama followed by Savitri and Tillotoma at all stages crop growth (Table 3). This might be due to higher translocation of photosynthetic was possible due to better sink capacity of cv. Rama than cv. Savitri and Tillotoma as indicated by higher number of capsules and seed weight plant^{-1} in cv. Rama. Crop growth rate not found to be significant. The highest (16.26 and 15.03 in between 60-75 DAS) was recorded in cultivar Rama followed by Savitri and Tillotoma during both the years of experimentation respectively (Table 4). The interaction effect of date of sowing and cultivars was not significant for all growth parameters.

Effect of dates of sowing and cultivars on yield components of sesame

Irrespective of sowing dates and improved cultivars, the number of branches plant kept on increasing till the last observation recorded at harvest. The number of branches plant^{-1} increased with the advancement of the crop age due to its growth and reached its maximum at harvest irrespective of the treatments tried (Table 5). The number of branches plant^{-1} was found significant due to the effect of date of sowing however, it was found non-significant due to the effect of cultivars. This might be influenced by the environment which could have counted for the fewer branches in sown crops because of the change in the environmental condition that forces the crop to reduce vegetative growth and commence reproductive phase as reported by Kifiriti and Deckers (2001). Peter and Yakubu (2012) reported that number of branches per plant decreased due to delay in time of sowing. The number of capsules plant^{-1}, number of grains capsule^{-1} and test weight of seed (1000 seed weight) was found significant due to the effect of date of sowing and cultivars. Among the varying date of sowing, 2nd day of March (D_3) recorded significantly higher number of branches plant, number of capsule plant, number of seeds plant and test weight as compared to other dates of sowing and 10th February (D_1) was recorded the lowest number of branches plant^{-1}, number of capsule plant^{-1}, number of seeds capsule^{-1} and test weight during both years of experimentation respectively (Table 5). The increase in the number of capsule plant^{-1} might be due to the environment and length of growth period has significantly influenced on number of capsule plant^{-1}. Similar result also made by Kifiriti and Deckers (2001). This might be due to the increased growth of crop and better utilization of light by crop. Abdel et al. (2007) reported that delaying the sowing date decreased number of capsules plant^{-1} and test weight (1000-seed). However, Patil et al*.* (1992) reported that increased number of capsule plant^{-1} with delaying sowing might be due to difference in genetic makeup and climatic conditions. This finding was in agreement with the result obtained by Nath et al*.* (2000) and Rai et al*.* (1999).

Among the different cultivars number of branches plant^{-1}, number of capsule plant^{-1}, number of seeds capsule^{-1} of sesame was found significantly influenced due to the effect of cultivars but test weight of sesame was not significantly influenced due to the effect of cultivars. However, variety Rama (V_1) was recorded higher number of branches plant^{-1}, number of capsule plant^{-1}, number of seeds capsule^{-1} and test weight as compared to Savitri and Tillotama during both the years of experimentation respectively (Table 5). This might be due to improved crop growth duration, availability of soil moisture and absorption of nutrients by crops which enhanced the crop growth, increase in yield attributing characters and ultimately yield. Increasing seed rate significantly decreased the number of capsules plant^{-1} and seed yield per sesame plant (Sudan Ahmed et al., 2012) and protein content (Caliskan et al*.*, 2004). The interaction effect between date of sowing and cultivars was non-significant.

Seed yield, stem yield and harvest index

Irrespective of different sowing dates of sesame, 2nd day

Table 5. Effect of dates of sowing and cultivars on yield attributes of sesame.

Treatments	Yield attributes											
	No. of branches plant^{-1}			No. of capsules plant^{-1}			No. of seeds capsule^{-1}			Test weight (g)		
	YI	YII	Pooled	YI	YII	Pooled	YI	YII	Pooled	YI	YII	Pooled
D_1	4.22	2.90	3.56	54.44	53.22	53.83	46.66	43.22	44.94	2.40	2.33	2.36
D_2	4.03	3.26	3.65	57.55	59.37	58.46	47.85	47.29	47.57	2.54	2.55	2.54
D_3	4.91	4.09	4.50	72.11	65.25	68.68	50.70	50.29	50.50	2.74	2.60	2.67
D_4	4.77	3.48	4.12	64.07	58.88	61.48	47.96	49.14	48.55	2.67	2.54	2.61
D_5	4.47	3.14	3.81	60.74	54.48	57.61	47.96	46.48	46.55	2.50	2.57	2.54
S. Em. (±)	**0.12**	**0.24**	**0.14**	**2.92**	**1.59**	**1.98**	**1.12**	**1.80**	**1.36**	**0.01**	**0.08**	**0.04**
C.D. (0.05)	**0.41**	**0.81**	**0.48**	**9.54**	**5.20**	**6.46**	**3.68**	**5.88**	**4.46**	**0.05**	**0.26**	**0.13**
V_1	4.75	3.61	4.18	65.35	62.17	63.76	49.68	49.48	49.58	2.68	2.61	2.65
V_2	4.41	3.44	3.92	61.68	59.06	60.37	47.86	47.51	47.68	2.57	2.57	2.57
V_3	4.28	3.08	3.68	58.31	53.48	55.90	46.33	44.86	45.60	2.46	2.37	2.41
S. Em. (±)	**0.14**	**0.15**	**0.12**	**2.31**	**2.25**	**1.45**	**0.71**	**1.33**	**0.70**	**0.02**	**0.04**	**0.02**
C.D. (0.05)	**NS**	**NS**	**NS**	**NS**	**6.65**	**4.28**	**2.10**	**NS**	**2.09**	**NS**	**NS**	**NS**
D_1V_1	4.55	3.10	3.82	57.00	57.66	57.33	48.77	46.00	47.38	2.48	2.33	2.40
D_1V_2	4.33	2.93	3.63	55.33	53.33	54.33	46.00	44.00	45.00	2.40	2.56	2.48
D_1V_3	3.78	2.68	3.23	51.00	48.66	49.83	45.22	39.66	42.44	2.32	2.10	2.21
D_2V_1	4.22	3.56	3.89	63.33	64.33	63.83	49.11	49.77	49.44	2.64	2.69	2.67
D_2V_2	4.11	3.40	3.58	57.44	60.77	59.11	47.67	47.67	47.66	2.54	2.56	2.55
D_2V_3	5.44	2.83	3.47	51.88	53.00	52.44	46.77	44.44	45.61	2.43	2.40	2.41
D_3V_1	4.72	4.30	4.87	75.00	67.22	71.11	52.11	52.66	52.38	2.85	2.73	2.79
D_3V_2	4.56	4.09	4.40	71.88	65.11	68.50	50.77	49.89	50.33	2.73	2.63	2.68
D_3V_3	5.00	3.88	4.22	69.44	63.44	66.44	49.22	48.33	48.77	2.63	2.43	2.53
D_4V_1	4.66	3.77	4.38	66.55	62.66	64.61	49.66	50.55	50.11	2.80	2.70	2.75
D_4V_2	4.64	3.55	4.11	63.77	61.33	62.55	48.33	49.00	48.66	2.69	2.53	2.61
D_4V_3	4.56	3.11	3.87	61.88	52.66	57.27	45.89	47.89	46.88	2.54	2.40	2.47
D_5V_1	4.55	3.33	3.95	64.88	59.00	61.94	48.77	48.44	48.61	2.62	2.63	2.62
D_5V_2	4.31	3.22	3.88	60.00	54.77	57.38	46.55	47.00	46.77	2.52	2.56	2.54
D_5V_3	4.48	2.89	3.59	57.33	49.66	53.50	44.55	44.00	44.27	2.37	2.53	2.45
	DX V / **VX D**	**DX V** / **VX D**	**D X V** / **V X D**	**DX V** / **V X D**	**D X V** / **V X D**	**D X V** / **V X D**	**D X V** / **V X D**	**D X V** / **V X D**	**D X V** / **V X D**	**D X V** / **VX D**	**D X V** / **VX D**	**DX V** / **V X D**
S. Em. (±)	**0.33** / **0.30**	**0.35** / **0.37**	**0.27** / **0.26**	**5.18** / **5.14**	**5.04** / **4.41**	**3.24** / **3.30**	**1.59** / **1.72**	**2.98** / **3.03**	**1.58** / **1.88**	**0.04** / **0.04**	**0.09** / **0.11**	**0.04** / **0.05**
C.D. (0.05)	**NS** / **NS**	**NS** / **NS**	**NS** / **NS**	**NS** / **NS**	**NS** / **NS**	**NS** / **NS**	**NS** / **NS**	**NS** / **NS**	**NS** / **NS**	**NS** / **NS**	**NS** / **NS**	**NS** / **NS**

YI= 2013 & YII=2014; DI=10th February, D2=20th February, D3=2nd March, D4=12th March, D5=22nd March and V1= Rama, V2= Savitri & V3= Tillotama.

of March (D_3) significantly produced highest seed and stem yield as compared to other dates of sowing. The highest seed yield with the sowing date of 2nd March was due to significantly higher number of primary branches, number of capsules plant^{-1}, number seeds capsule^{-1}, test weight (1000 seed weight), total dry matter accumulation and number of branches plant^{-1}. Sesame yield was significantly influenced by sowing dates and genotype. The lowest seed yield and stem yield was recorded when sesame was shown on 22nd March (D_5). Increased seed yield might be due to number of factors, which has direct or indirect impact. The main factors, responsible for high seed yield are the seed weight plant^{-1}, number of capsule plant^{-1}, number of seeds capsule^{-1}, test weight (1000-seed weight) and harvest index. Early and late sowing of sesame decreased its

Table 6. Effect of dates of sowing and cultivars on grain yield, stover yield and harvest index of sesame.

Treatments	Seed yield (kg ha^{-1})			Stem yield (kg ha^{-1})			Harvest index (%)		
	YI	YII	Pooled	YI	YII	Pooled	YI	YII	Pooled
D_1	493.72	480.11	486.91	1975.33	1982.22	1978.77	19.96	19.53	19.74
D_2	542.18	536.66	539.42	2462.22	2362.22	2412.22	18.23	18.75	18.51
D_3	648.53	609.11	628.82	2733.33	2633.33	2683.33	19.41	19.05	19.24
D_4	620.37	558.88	589.63	2705.56	2605.57	2655.55	19.31	18.35	18.85
D_5	415.74	432.44	424.09	2253.33	2141.22	2197.27	15.80	16.86	16.30
S. Em. (±)	**19.16**	**19.29**	**13.44**	**146.38**	**141.84**	**140.42**	**1.02**	**1.03**	**0.86**
C.D. (0.05)	**62.51**	**62.94**	**43.84**	**477.38**	**462.58**	**457.97**	**NS**	**NS**	**NS**
V_1	593.23	556.13	574.68	2467.00	2404.67	2435.83	19.49	18.93	19.21
V_2	535.10	517.93	526.51	2415.00	2334.40	2374.70	18.46	18.49	18.48
V_3	504.00	496.26	500.13	2395.86	2295.66	2345.76	17.68	18.11	17.89
S. Em. (±)	**13.78**	**10.64**	**7.50**	**60.10**	**54.11**	**54.94**	**0.46**	**0.49**	**0.35**
C.D. (0.05)	**40.67**	**31.40**	**22.13**	**NS**	**NS**	**NS**	**1.37**	**NS**	**1.03**
D_1V_1	525.55	495.00	510.27	2041.66	2016.67	2029.16	20.35	19.75	20.05
D_1V_2	500.94	486.66	493.80	1988.33	1985.33	1986.83	20.17	19.68	19.94
D_1V_3	454.66	458.66	456.66	1896.00	1944.67	1920.33	19.36	19.15	19.22
D_2V_1	610.66	577.66	594.16	2483.33	2383.33	2433.33	20.05	19.79	19.93
D_2V_2	514.89	519.66	617.27	2470.00	2370.00	2420.00	17.53	18.16	17.85
D_2V_3	501.00	512.66	506.83	2433.33	2333.33	2383.33	17.12	18.31	17.74
D_3V_1	713.66	648.66	681.16	2850.00	2750.00	2800.00	20.21	19.28	19.76
D_3V_2	627.78	606.66	617.22	2650.00	2550.00	2600.00	19.57	19.73	19.65
D_3V_3	604.16	572.00	588.08	2700.00	2600.00	2650.00	18.46	18.15	18.32
D_4V_1	667.66	610.00	638.83	2716.68	2616.67	2666.66	20.05	19.14	19.61
D_4V_2	609.66	545.66	577.66	2800.00	2700.00	2750.00	18.67	17.61	18.16
D_4V_3	583.77	521.00	552.38	2600.00	2500.00	2550.00	19.23	18.31	18.79
D_5V_1	448.61	449.33	8.97	2243.33	2256.67	2250.00	16.82	16.67	16.72
D_5V_2	422.22	431.00	426.61	2166.67	2066.67	2116.66	16.35	17.28	16.83
D_5V_3	376.39	417.00	396.69	2350.00	2100.33	2225.16	14.23	16.64	15.36

	Seed YI		Seed YII		Seed Pooled		Stem YI		Stem YII		Stem Pooled		HI YI		HI YII		HI Pooled	
	D X V	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**V X D**	**V X D**
S. Em. (±)	**30.83**	**31.64**	**23.80**	**27.39**	**16.77**	**19.19**	**134.38**	**182.94**	**0.78**	**172.86**	**122.85**	**172.57**	**1.03**	**1.32**	**1.10**	**1.37**	**1.11**	**1.07**
C.D. (0.05)	**NS**	**96.95**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

YI= 2013 & YII=2014; DI=10th February, D2=20th February, D3=2nd March, D4=12th March, D5=22nd March and V1= Rama, V2= Savitri & V3= Tillotama.

seed yield (Rai et al., 1999; Saha et al., 1993). This result closely resembles to that obtained by Ieda et al. (1999) who also opined that delaying in sowing decreased seed yields of sesame. The results indicated that sowing of sesame within 2nd March to 12th March is the optimum sowing date for sesame to have optimum seed yield. Among the varieties, Rama (V_1) recorded significantly highest seed and stem yield as compared to Savitri (V_2) and Tillotama (V_3) during both the years of experimentation respectively (Table 6). However, the yield of Savitri (V_2) was statistically at par with Tillotama (V_3) (Table 6). This might be due to difference in genetic makeup of crop plants, varying date of sowing and climatic condition. These result also corroborated with the findings of several workers Suryavanshi et al. (1993) and Sarkar et al. (2007). Such differences in cultivars with respect to seed yield have been reported by Dixit et al. (1997) and Basavaraj et al*.* (2000).

Harvest index (HI) is another important parameter to assess the translocation efficiency. Seed yield is related to biological yield through harvest index (Yoshida, 1972). Further, it was also reported that the yielding potentiality of a cultivar is associated with increased seed to stalk ratio (HI). Harvest index was not significantly influenced due to the effect of dates of sowing. However, it was significantly influenced due to the effect of cultivars during both years of experimentation respectively (Table 6). The highest harvest index was recorded under 10th February (D_1) (19.96 and 19.53%) and lowest harvest index was recorded on 22nd March (D_5) (15.80 and 16.86%). Ali et al. (2005) reported that harvest index significantly influenced by date of sowing. Among the varieties, Rama (V_1) recorded higher harvest index (19.49 and 18.93%) as compared to Savitri (17.78 and 18.23%) and Tillotama recorded (17.68 and 18.11%) during both the years of experimentation respectively. Interaction effect between date of sowing and cultivars was not significant.

Conclusion

It may be inferred that the cultivar Rama can be adopted in North Bengal during summer season, because of its highest seed yield ability and 2nd March to 12th March is the optimum sowing dates of sesame to have optimum seed yield if grown as late summer crop.

Conflict of Interest

The authors have not declared any conflict of interest.

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