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Olfactometer studies of *Sitophilus oryzae* L. feeding on sorghum and split pulses

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Abstract
Behavioral responses of *Sitophilus oryzae* to odours/volatiles from sorghum, red gram, chick pea, black gram, green gram, fried gram and lentil were compared in olfactometer bioassay. Results indicated that sorghum populations were more attracted towards sorghum followed by split pulses. Whereas pulses populations were more attracted towards red gram followed by green gram, chick pea, black gram, lentil and fried gram. In eight arm olfactometer 65.33 per cent females and 59.33 per cent males of sorghum population oriented towards the uninfested sorghum grains at 30 Minutes After Release (MAR). The same trend was observed in infested hosts. The maximum orientation of females and males was observed in sorghum (74.00 and 64.67%) at 30 MAR when compared to uninfested grains. In case of pulse population 32.00 per cent females and 30.67 per cent males preferred uninfested redgram followed by green gram (24.00 and 22.65%) and chick pea (17.33 and 14.00 %) at 30 MAR. The same trend was observed in infested hosts, while 36.0 per cent females and 32.67 per cent males preferred infested redgram followed by green gram (28.67 and 26.00%) and chickpea (15.33 and 16.00 %) at 30 MAR when compared to uninfested grains.

Keywords: Olfactometer, *Sitophilus oryzae* L., sorghum and split pulses

Introduction
The rice weevil, *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae), is one of the most destructive pest of stored cereals worldwide. It is classed as a primary pest, one which can easily infest sound cereal seeds (Hill, D. S, 1990) [10]. It is the most cosmopolitan in nature, and causes severe losses in rice, maize, barley, wheat, and other crops (Neupane, F. P, 1995) [16]. Storage grain losses of major cereal crops can be attributed primarily to attack by insect pests, pathogens, and rodents. Currently, the primary means of rice weevil control in warm climates is the use of fumigants and residual chemical insecticides (Faruki *et al*., 2005 and Moharramipour, 2007) [8, 15]. Synthetic chemical pesticides are usually applied by the farmers to reduce losses during storage (Adane *et al*., 1996) [1]. In recent years, however, the overreliance and the use of chemical insecticides in crop pest control programs (around the world) has resulted in environmental damage, pest resurgence, pest resistance to insecticides, and lethal effects on non-target organisms. Furthermore, because of cost, these pesticides are becoming increasingly inaccessible to farmers, particularly in developing countries. This fact, combined with the consumer's demand for residue-free food, prompted researchers to evaluate other alternative reduced risk control methods for stored-grain protection. These methods include, among others, the application of chemical ecology in the control of stored-grain insects. Semiochemical-based pest management systems in stored-products are being necessitated by the withdrawal of approval for use of many synthetic insecticides and the fumigant methyl bromide. Control often depends on a sound knowledge of the ecology and on the effects of a multitude of environmental factors on the life history of a pest. It is a primary pest of stored rice, sorghum, cumbu and maize and reports about its occurrence on legumes is scanty. Pemberton *et al.*, (1981) [18] studied its breeding behaviour on carob, *Ceratonia siliqua* (L.), a tree legume native to the Mediterranean region. Coombs *et al.*, (1977) [4] reported the successful development by Trinidad strain of *S. oryzae* on yellow split pea. Infochemical cues are generally considered to play a pivotal role in the location, evaluation and utilization of hosts by herbivorous insects (Francis *et al.*, 2005) [9]. Numerous species of insects have been shown to be attracted to (single or blends of) volatiles of their host plants (Visser, 1986) [20]. The response of maize weevil to olfactory stimuli has been demonstrated earlier and food-related odours may contain potential attractants (Honda, and Oshawa, 1990. Ben, and Xuan, 1992) [12, 3]. However, it is not clear whether *S. zeamais* is capable of using olfactory cues to discriminate between volatiles from suitable and unsuitable plant species during the host-

finding process. The present investigation was carried out to compare host preference of population collected from red gram dhal to other split pulses and the normal population that occurs on sorghum.

Materials and Methods

The experiment was conducted by using eight arm olfactometer. About 10 g of uninfested hosts was kept in each arm and was firmly closed with a lid. The inlet of the olfactometer on the top center place was connected to an aquarium pump or vaccum pump (220-240 volt AC) to release the pressure. Out of eight arms, one arm was treated as control. The pure air was passed from aquarium pump at the rate of 4 lit./ min. in to the olfactometer. After five minutes of saturation of different host odour in the olfactometer, 50 insects were allowed through a central hole, which also served as an odour exit hole. Observation was made on number of insects settled on each arm at 0, 5, 10, 15, 20, 25 and 30 Minutes after Release (MAR) for their host preference. This experiment was replicated three times. Similarly, another experiment was conducted using the infested hosts. The response of male, female and combined sex of sorghum and pulse population was assessed both on infested and uninfested grains. The data on number of insects settled and unsettled insects on each arm were recorded. The treatment details of the olfactometer studies conducted were given below.

Eight arm Olfactometer

Treatment	Experiment 1	Experiment 2
T_1	Sorghum uninfested	Sorghum infested
T_2	Red gram uninfested	Red gram infested
T_3	Chick pea uninfested	Chick pea infested
T_4	Black gram uninfested	Black gram infested
T_5	Green gram uninfested	Green gram infested
T_6	Fried gram uninfested	Fried gram infested
T_7	Lentil uninfested	Lentil infested
T_8	Untreated check	Untreated check

Results and Discussion

The results showed significant variation on orientation behavior of *S. oryzae* towards sorghum and split pulses in eight arm olfactometer. In eight arm olfactometer seven different hosts *viz.*, sorghum, redgram, chick pea, black gram, green gram, fried gram and lentil were used with untreated check. The results of eight arm olfactometer showed significant variation in orientation behavior of *S. oryzae* towards sorghum and split pulses. At 20 MAR, the highest orientation (53.33 and 48.67%) recorded towards sorghum grains and was found to be significantly superior to other hosts. At 30 MAR 65.33 per cent females and 59.33 per cent males of sorghum population orientated towards the uninfested sorghum. Among the split pulses the maximum orientation of females and males was observed in uninfested redgram (7.33and 6.00%) and green gram (3.33 and 2.67%) followed by other hosts respectively (Table 1). The same trend was observed in infested hosts. The maximum orientation of females and males was observed in sorghum (74.00 % and 64.67%) followed by redgram (8.00 and 4.67%) and green gram (3.33 and 2.67%) at 30 MAR when compared to uninfested grains (Table 2).

In case of pulse population the female and male adults of *S. oryzae* were oriented towards uninfested redgram (16.67 and 14.00 %, 30.00 and 24.67 %) followed by green gram (14.67 and 11.33 %, 22.67 and 17.33 %) at 10 and 20 MAR respectively.

At 30 MAR, 32.00 per cent females and 30.67 per cent males settled in uninfested redgram followed by green gram (24.00 and 22.65%) and chick pea (17.33 and 14.00 %) respectively (Table 3). Similarly in infested hosts, 36.0 per cent females and 32.67 per cent males oriented towards infested redgram followed by green gram (28.67 and 26.00 %) and chickpea (15.33 and 16.00 %) at 30 MAR. The least preference was recorded in fried gram under infested and uninfested grains of respective sorghum and pulse population (Table 4). The present findings are in accordance with Edde and Phillips (2006) [7] who reported, strongest indications of a response by *R. dominica* (82% of beetles) to food volatiles. Nguyen (2006) who reported the locomotory responses of *R. dominica* towards food odour sources. On an average, 37 per cent beetles arrived at the clean food sources while 80 per cent of them were able to locate the wheat previously infested by conspecifics. Dowdy *et al*. (1993) [6] reported that only 9.8 per cent of beetles orientated to clean wheat compared to 64.7% responding to infested wheat. In present investigation orientation of attraction was maximum in females when compared to males. This finding is in accordance with Edde and Phillips (2006) [7] who reported that females showed a direct chemo-orthokinetic reaction as they walked faster than males in response to infested wheat. Bashir *et al.* (2000) [2] made the same observation who reported that infested wheat that contains the aggregation pheromone released by males was more attractive to females than to males. Landolt and Phillips (1997) [14] reported that in *R. dominica* the aggregation pheromone signals females about the availability of both mates and food resources. Therefore, this behaviour of female *R. dominica* is expected and it is similar to the behaviour of female *Prostephanus truncatus*- a species closely related to *R. dominica*- in their response to synthetic pheromone (Hodges and Dobson, 1998; Scholz *et al.* 1998) [11, 19].

Based on the observation made in eight arm olfactometer maximum percentage of preference was recorded in infested grains when compared to uninfested grains. The females were highly attracted when compared to male. Sorghum breeding population was highly attracted to sorghum, whereas pulse breeding population preferred redgram and green gram followed by other split pulses.

In present investigation, maximum percentage of preference was recorded in infested grains when compared to uninfested grains. Kennedy (1978) [13] reported that an increase in female velocity (orthokinesis), pheromone in the infested wheat resulted in both female and male *R. dominica* showing an increase in their frequency of turning (klinokinesis). Therefore infested wheat can be an attractant, as both males and females oriented toward the odour source and/or an arrestant due to orthokinetic and klinokinetic responses. Crombie (1941) [5] reported that beetles that actually reached clean wheat were attracted by the wheat itself then their locomotory reactions would be expected to be different from those of beetles exposed to clean air, i.e. walking in an empty arena with airflow. If beetles locating clean wheat were considered to be ‘responders’, they would show different locomotory responses from beetles that failed to reach food. However, it was not possible to identify differences in locomotory behavior (velocities and angular velocities) between beetles exposed to food odours or to clean air and neither could they be identified as ‘responders’ or ‘non-responders’ to clean wheat odours on the basis of locomotory behaviour.

Table 1: Olfactometer studies of *S. oryzae* (Sorghum population) feeding on uninfested grains (Eight arm)

S. No	Treatments	Number of weevils settled (%)											
		Minutes After Release (MAR)											
		Female*						Male*					
		5 MAR	10MAR	15 MAR	20 MAR	25 MAR	30 MAR	5 MAR	10MAR	15 MAR	20 MAR	25 MAR	30 MAR
1.	Sorghum	17.33 (24.60)^{b}	26.67 (31.07^{b}	36.67 (37.26^{b}	53.33 (46.91)^{a}	59.33 (50.38)^{a}	65.33 (53.94)^{a}	16.67 (24.09)^{b}	24.00 (29.32)^{b}	34.00 (35.63)^{b}	48.67 (44.23)^{a}	51.33 (46.72)^{a}	59.33 (50.39)^{a}
2.	Red gram	2.67 (9.27)^{c}	4.67 (12.42^{c}	6.00 (14.25^{C}	7.33 (15.68)^{c}	7.33 (15.68)^{c}	7.33 (15.68)^{c}	2.67 (9.27)^{c}	4.67 (12.42)^{c}	4.67 (12.42)^{c}	6.00 (14.05)^{c}	6.00 (14.05)^{c}	6.00 (14.05)^{c}
3.	Chick Pea	0.67 (3.81)^{de}	1.33 (5.97)^{de}	2.67 (9.27)^{cd}	3.33 (10.40)^{d}	3.33 (10.40)^{d}	3.33 (10.40)^{d}	0.67 (3.81)^{de}	2.00 (8.13)^{cd}	2.67 (9.27)^{cd}	3.33 (10.40)^{cd}	3.33 (10.40)^{cd}	3.33 (10.40)^{cd}
4.	Black gram	0.00 (1.65)^{e}	1.33 (5.97)^{de}	2.00 (7.11)^{d}	2.00 (7.11)^{de}	2.00 (7.11)^{d}	2.00 (7.11)^{d}	0.00 (1.65)^{e}	1.33 (5.97)^{de}	2.00 (7.11)^{d}	2.00 (8.13)^{de}	2.00 (8.13)^{d}	2.67 (9.27)^{d}
5.	Green gram	1.33 (1.65)^{cd}	2.00 (7.11)^{d}	2.67 (9.27)^{cd}	2.67 (9.27)^{d}	3.33 (10.40)^{d}	3.33 (10.40)^{d}	1.33 (5.97)^{cd}	2.00 (7.11)^{d}	2.67 (9.27)^{cd}	2.67 (9.27)^{c}	2.67 (9.27)^{d}	2.67 (9.27)^{d}
6.	Fried gram	0.00 (1.65)^{e}	0.00 (1.65)^{e}	0.00 (1.65)^{e}	0.67 (3.81)^{e}	1.33 (10.40)^{d}	1.33 (5.97)^{d}	0.00 (1.65)^{e}	0.00 (1.65)^{e}	0.00 (1.65)^{e}	0.67 (3.81)^{e}	1.33 (5.97)^{d}	0.67 (3.81)^{e}
7.	Lentil	0.00 (2.65)^{e}	0.00 (1.65)^{e}	1.33 (5.97)^{de}	1.33 (5.97)^{de}	2.00 (8.13)^{d}	2.00 (8.13)^{d}	0.00 (1.65)^{e}	0.67 (3.81)^{de}	2.00 (7.11)^{cd}	1.33 (5.97)^{de}	2.00 (8.13)^{d}	2.00 (8.13)^{d}
8.	Control	0.67 (3.81)^{de}	1.33 (5.97)^{de}	2.67 (9.27)^{cd}	2.00 (7.11)^{de}	2.00 (8.13)^{d}	2.00 (8.13)^{d}	0.67 (3.81)^{de}	1.33 (5.97)^{de}	2.67 (9.27)^{cd}	2.00 (8.13)^{de}	2.00 (8.13)^{d}	2.00 (8.13)^{d}
9.	Unsettled	77.40 (61.58)^{a}	62.66 (52.37^{a}	46.00 (42.69)^{a}	27.33 (31.45)^{b}	19.33 (25.94)^{b}	13.33 (21.37)^{b}	78.00 (62.04)^{a}	64.00 (53.17)^{a}	49.34 (44.63)^{a}	33.33 (35.22)^{b}	29.33 (30.66)^{b}	21.33 (27.42)^{b}
		SEd	1.8699	2.4695	2.4347	2.4198	2.3428	2.1524	1.8954	2.4564	2.4027	2.5048	2.2584
		CD Value (0.05)	3.9286	5.1883	5.1152	5.0838	4.9221	4.5221	3.9822	5.1608	5.0479	5.2624	4.7448

*Mean of three replications. Figures in parentheses are arc sin transformed values. Mean followed by same letter (s) in a column are not significantly different by DMRT (P=0.05)

Table 2: Olfactometer studies of *S.oryzae* (Sorghum population) feeding on infested grains (Eight arm)

S. No	Treatments	Number of weevils settled (%)											
		Minutes After Release (MAR)											
		Female*						Male*					
		5 MAR	10MAR	15 MAR	20 MAR	25 MAR	30 MAR	5 MAR	10MAR	15 MAR	20 MAR	25 MAR	30 MAR
1.	Sorghum	17.33 (24.60)^{b}	26.67 (31.67)^{b}	36.67 (37.26)^{a}	53.33 (46.91)^{a}	60.33 (50.96)^{a}	74.00 (53.94)^{a}	22.00 (27.96)^{b}	28.67 (32.35)^{b}	36.00 (36.87)^{b}	47.33 (43.47)^{a}	54.67 (47.68)^{a}	64.67 (53.53)^{a}
2.	Red gram	2.67 (9.27)^{c}	4.67 (12.42)^{c}	6.00 (14.05)^{b}	7.33 (15.68)^{bc}	7.33 (15.71)^{b}	8.00 (15.68)^{b}	2.67 (9.27)^{c}	4.00 (11.54)^{c}	3.33 (10.40)^{c}	3.33 (10.40)^{b}	4.00 (11.28)^{c}	4.67 (12.42)^{c}
3.	Chick pea	0.67 (3.81)^{d}	1.33 (5.97)^{de}	2.67 (9.27)^{bc}	3.33 (10.40)^{cd}	3.33 (10.52)^{cd}	3.33 (10.40)^{cd}	2.00 (7.11)^{c}	2.67 (9.27)^{c}	2.00 (7.11)^{cd}	1.33 (5.97)^{bc}	2.67 (9.27)^{c}	2.67 (9.27)^{cd}
4.	Black gram	0.00 (1.65)^{d}	1.33 (5.97)^{de}	2.00 (7.11)^{c}	2.00 (7.11)^{de}	2.00 (8.13)^{de}	2.00 (7.11)^{d}	0.67 (3.81)^{c}	0.67 (3.81)^{e}	2.00 (7.11)^{cd}	1.33 (5.97)^{bc}	1.33 (5.97)^{cd}	1.33 (5.97)^{de}
5.	Green gram	1.33 (5.97)^{cd}	2.00 (7.11)^{d}	2.67 (9.27)^{bc}	2.67 (9.27)^{de}	3.33 (10.40)^{de}	3.33 (10.40)^{c}	1.33 (5.97)^{c}	2.67 (9.27)^{c}	2.67 (9.27)^{c}	2.00 (7.11)^{bc}	2.00 (7.11)^{cd}	2.67 (9.27)^{cd}
6.	Fried gram	0.00 (1.65)^{d}	0.00 (1.65)^{e}	0.00 (1.65)^{d}	0.67 (3.81)^{e}	1.33 (5.97)^{e}	1.33 (5.97)^{d}	0.67 (3.81)^{c}	0.67 (3.81)^{e}	0.67 (3.81)^{d}	0.67 (3.81)^{c}	1.33 (5.97)^{cd}	1.33 (5.97)^{de}
7.	Lentil	0.00 (1.65)^{d}	0.00 (1.65)^{e}	1.33 (5.97)^{cd}	1.33 (5.97)^{de}	2.00 (7.11)^{cd}	2.00 (7.11)^{cd}	0.67 (3.81)^{c}	0.67 (3.81)^{e}	1.33 (5.97)^{cd}	1.33 (5.97)^{bc}	2.00 (7.11)^{cd}	0.67 (3.81)^{e}
8.	Control	0.67 (3.81)^{d}	1.33 (5.97)^{de}	2.67 (9.27)^{bc}	2.00 (7.11)^{de}	1.00 (5.74)^{cd}	2.00 (7.11)^{cd}	1.33 (5.97)^{c}	2.00 (7.11)^{ce}	2.00 (7.11)^{cd}	1.33 (5.97)^{bc}	0.67 (3.81)^{d}	1.33 (5.97)^{de}
9.	Unsettled	64.00 (61.58)^{a}	48.00 (43.65)^{a}	32.00 (34.30)^{a}	12.00 (19.73)^{b}	4.67 (12.42)^{bc}	4.67 (12.42)^{bc}	68.60 (56.03)^{a}	58.00 (49.61)^{a}	50.00 (45.00)^{a}	41.33 (40.01)^{a}	31.33 (34.00)^{b}	20.66 (27.44)^{b}
	SEd	2.0993	2.3931	2.5686	2.7925	2.1032	2.1295	2.9188	2.0633	2.5654	2.4136	2.5869	2.3531
	CD Value (0.05)	4.4105	5.0278	5.3966	5.8670	4.4187	4.4739	6.1324	4.3349	5.3897	5.0709	5.4350	4.9438

*Mean of three replications. Figures in parentheses are arc sin transformed values. Mean followed by same letter (s) in a column are not significantly different by DMRT (P=0.05)

Table 3: Olfactometer studies of *S.oryzae* (Pulse population) feeding on uninfested grains (Eight arm)

S. No	Treatments	Number of weevils settled (%)											
		Minutes After Release (MAR)											
		Female*						Male*					
		5 MAR	10MAR	15 MAR	20 MAR	25 MAR	30 MAR	5 MAR	10MAR	15 MAR	20 MAR	25 MAR	30 MAR
1.	Sorghum	2.67 (9.40)^{cd}	3.33 (10.52)^{de}	3.33 (10.52)^{d}	3.33 (10.52)^{d}	3.33 (10.52)^{ef}	3.33 (10.52)^{e}	2.67 (9.40)^{de}	2.67 (9.40)^{d}	3.33 (10.52)^{de}	4.00 (11.54)^{de}	3.33 (10.52)^{d}	3.33 (10.52)^{de}
2.	Red gram	11.33 (19.67)^{b}	16.67 (24.09)^{b}	28.67 (32.37)^{a}	30.00 (33.21)^{a}	31.33 (33.21)^{a}	32.00 (34.45)^{a}	10.67 (19.06)^{b}	14.00 (21.97)^{b}	16.67 (24.09)^{b}	24.67 (29.78)^{a}	30.00 (33.21)^{a}	30.67 (33.67)^{a}
3.	Chick pea	4.67 (12.48) c	6.67 (14.96)^{c}	14.67 (22.52)^{c}	17.33 (24.60)^{bc}	17.33 (24.60)^{c}	17.33 (24.60)^{c}	4.67 (12.48)^{cd}	5.33 (13.35)^{c}	7.33 (15.71)^{c}	10.00 (18.43)^{c}	14.00 (21.97)^{bc}	14.00 (21.97)^{b}
4.	Black gram	2.67 (9.40)^{cd}	2.00 (8.13)^{e}	4.00 (11.54)^{d}	4.67 (12.48)^{d}	5.33 (12.48)^{de}	5.33 (13.35)^{e}	2.00 (8.13)^{ef}	2.67 (9.40)^{d}	2.67 (9.40)^{ef}	3.33 (10.52)^{e}	4.67 (12.48)^{c}	4.67 (12.48)^{de}
5.	Green gram	8.67	14.67	21.33	22.67	24.00	24.00	7.33	11.33	14.67	17.33	23.33	22.65

		(17.12)[b]	(22.52)[b]	(27.51)[b]	(28.43)[b]	(29.33)[b]	(28.42)[b]	(15.71)[bc]	(19.67)[b]	(22.52)[b]	(24.60)[ab]	(28.88)[a]	(29.78)[a]
6.	Fried gram	2.67 (9.40)[cd]	3.33 (10.52)[de]	2.67 (9.40)[d]	2.67 (9.40)[de]	2.67 (9.40)[fg]	4.00 (12.49)[e]	2.00 (8.13)[ef]	2.67 (9.40)[d]	2.67 (9.40)[ef]	2.67 (9.40)[ef]	2.67 (9.40)[cd]	2.67 (9.40)[ce]
7.	Lentil	3.33 (10.52)[c]	4.67 (12.48)[cd]	4.00 (11.54)[d]	4.00 (11.54)[d]	6.00 (14.18)[de]	10.00 (18.43)[d]	3.33 (10.52)[de]	4.00 (11.54)[c]	5.33 (14.96)[cd]	6.67 (14.96)[cd]	5.33 (13.35)[c]	7.33 (15.71)[d]
8.	Control	1.33 (6.63)[d]	2.00 (8.13)[e]	2.00 (8.13)[d]	1.33 (6.63)[e]	1.33 (6.63)[g]	1.33 (6.33)[f]	1.33 (6.63)[f]	2.00 (8.13)[d]	1.33 (6.63)[f]	1.33 (6.63)[f]	1.33 (6.63)[d]	0.67 (4.68)[f]
9.	Unsettled	62.60 (52.30)[a]	46.66 (43.08)[a]	19.33 (26.09)[bc]	14.00 (21.97)[c]	8.67 (17.12)[d]	3.33 (10.52)[e]	66.00 (54.33)[a]	55.34 (48.07)[a]	46.00 (33.21)[a]	30.00 (33.21)[a]	15.33 (23.05)[b]	12.00 (20.27)[bc]
	SEd	1.9275	1.3414	2.0491	1.8998	2.1452	1.9378	1.9911	1.3570	1.7924	1.7931	2.5130	2.6000
	CD Value (0.05)	4.0497	2.8182	4.3052	3.9913	4.5069	4.0713	4.1833	2.8509	3.7658	3.7673	5.2798	5.4625

*Mean of three replications. Figures in parentheses are arc sin transformed values. Mean followed by same letter (s) in a column are not significantly different by DMRT (P=0.05)

Table 4: Olfactometer studies of *S.oryzae* (Pulse population) feeding on infested grains (Eight arm)

S. No	Treatments	Number of weevils settled (%)											
		Minutes After Release (MAR)											
		Female*						Male*					
		5 MAR	10MAR	15 MAR	20 MAR	25 MAR	30 MAR	5 MAR	10MAR	15 MAR	20 MAR	25 MAR	30 MAR
1.	Sorghum	1.33 (6.63)[ef]	1.33 (6.63)[d]	1.33 (6.63)[f]	1.33 (6.63)[ef]	1.33 (6.63)[de]	1.33 (6.63)[f]	1.33 (6.63)[ae]	2.00 (8.13)[de]	2.67 (9.40)[d]	2.67 (9.40)[e]	3.33 (10.52)[de]	3.33 (10.52)[ef]
2.	Red gram	17.33 (24.60)[b]	26.67 (31.09)[a]	30.67 (33.63)[a]	33.33 (35.26)[a]	34.00 (35.67)[a]	36.00 (36.87)[a]	16.67 (24.09)[b]	18.67 (25.60)[b]	23.33 (28.88)[b]	29.33 (32.79)[a]	30.00 (33.21)[a]	32.67 (34.86)[a]
3.	Chick pea	6.67 (14.96)[c]	11.33 (19.67)[b]	13.33 (21.42)[c]	15.33 (23.05)[b]	15.33 (23.05)[b]	15.33 (23.05)[c]	5.33 (13.35)[c]	5.33 (13.35)[c]	8.00 (16.43)[c]	10.67 (19.06)[c]	13.33 (21.42)[c]	16.00 (23.58)[c]
4.	Black gram	3.33 (10.52)[d]	4.00 (11.54)[c]	4.67 (12.48)[de]	4.67 (12.48)[cd]	4.67 (12.48)[c]	4.67 (12.48)[e]	3.33 (10.52)[cd]	3.33 (10.52)[cd]	3.33 (10.52)[d]	3.33 (10.52)[de]	3.33 (10.52)[de]	5.33 (13.35)[de]
5.	Green gram	14.67 (22.52)[b]	20.67 (27.04)[a]	24.00 (29.33)[b]	26.00 (30.66)[a]	28.00 (31.95)[a]	28.67 (32.37)[b]	12.67 (20.85)[b]	14.67 (22.52)[b]	18.67 (25.60)[b]	20.00 (26.57)[b]	22.67 (28.43)[b]	26.00 (30.66)[b]
6.	Fried gram	2.67 (9.40)[de]	3.33 (10.52)[c]	3.33 (10.52)[e]	3.33 (10.52)[de]	3.33 (10.52)[cd]	3.33 (10.52)[e]	2.67 (9.40)[cd]	2.67 (9.40)[cd]	2.67 (9.40)[d]	2.67 (9.40)[e]	2.67 (9.40)[e]	2.67 (9.40)[f]
7.	Lentil	4.67 (12.48)[cd]	5.33 (13.35)[c]	7.33 (15.71)[d]	8.00 (16.43)[c]	9.33 (17.79)[b]	9.33 (17.79)[d]	4.00 (11.54)[c]	4.00 (11.54)[cd]	4.67 (12.48)[d]	6.00 (14.18)[d]	6.00 (14.18)[d]	5.33 (13.35)[de]
8.	Control	0.67 (4.68)[f]	0.67 (4.68)[d]	0.67 (4.68)[f]	0.67 (4.68)[f]	0.67 (4.68)[e]	0.67 (4.68)[f]	0.67 (4.68)[e]	0.67 (4.68)[e]	0.67 (4.68)[e]	0.67 (4.68)[f]	0.67 (4.68)[f]	0.67 (4.68)[g]
9.	Unsettled	64.00 (53.13)[a]	48.00 (43.85)[a]	32.00 (34.45)[c]	7.33 (15.71)[cd]	3.33 (10.52)[cd]	0.67 (4.68)[f]	53.40 (46.95)[a]	48.66 (44.23)[a]	36.00 (36.87)[a]	24.67 (29.78)[ab]	18.00 (25.10)[bc]	8.00 (16.43)[d]
	SEd	1.9163	1.9365	1.9147	2.4727	2.5158	2.0658	2.3670	2.2335	1.7896	1.7413	1.9909	1.7407
	CD Value (0.05)	4.0261	4.0685	4.0228	5.1951	5.2856	4.3402	4.9730	4.6925	3.7599	3.6583	4.1827	3.6571

*Mean of three replications. Figures in parentheses are arc sin transformed values. Mean followed by same letter (s) in a column are not significantly different by DMRT (P=0.05)

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