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Response of mungbean (*Vigna radiata* L., Wilczek) to gibberellic acid (GA_3) rates and varying irrigation frequencies

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Abstract

An attempt was made to investigate the response of mungbean local cultivar to irrigation frequencies and for improving its drought resistance capability by the application of 0, 100 and 200mg/l GA_3. Results showed that irrigating mungbean plants every 8 days drastically reduced plant height (46.8%), internodes length (32.1%), number leaves per plant (64.3%), leaf area per plant 9158.5%), leaf area index (179.3%), inflorescence number per plant (119%) pod length (22.6%), pod number per plant (117%), seed number per pod (23.8), biomass yield (74.6%), yield (91.3%) and seed yield per plant (83.7%). However, this treatment highly increased number first fruiting node (180.1%) and weight of 1000 seeds (11.5%). Treatments can be ordered due to their importance as below: 2days > 4days > 6days > 8days. Yield was linearly responded to irrigation frequencies and it can be estimated by the following equation: Y = 131.252 – 5.233 X, where (r^2=13). Mash plants treated by (200 mg.l^{-1} GA_3) substantially increased plant height (11.7%). However, treated plants highly reduced yield (12.5%) and harvest index (8.2%). However, other detected traits revealed non unequivocal differences with that of untreated plants. Yield showed linear response to GA_3 rates and it could be estimated from the below formula: Y = 114.698 – 0.064 X, where (r^2=2.4). 200 mg.l^{-1} GA_3 treated plants irrigated every 2 days appeared the most potent dual interaction treatment. Since it exhibited the highest values in terms of plant height (52.33 cm), internodes length (6.19), inflorescence number per plant (13), pod length 5.83 cm), pod number per plant (29), seed number per pod (9.33), biomass (502.22 g.m^{-2}), yield (165.91 g. m^{-2}) and seed weights per plant (4.36g).

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Introduction

Senthong and Pandey (1989) observed that green gram was quite sensitive to water stress, when compared to a series of other crops. The resulting small irrigation depth may be ineffective for green gram, which, it seems, grows its roots deeper into the soil profile to extract water resources from greater depths (Haqqani and Pandey, 1994). Mungbeans required pre-sowing 3-4 irrigations at 15-20 days interval are required. In summer season (grown after wheat), no irrigation should be given after 40-45 days of sowing. The water requirement varies with soil and climate from 15-30 cm (Malik *et al*., 2006). Pandey *et al*., (1984) found that irrigation increased the number of grains per pod. The reduction in seed weight in case of less irrigation water supply might be due to the decreased photosynthetic. Overall fewer yields recorded in treatments where less irrigation water was supplied may be related to contribution of yield attributes. Mungbean treated with biogin and watered every 5 days exhibited maximum growth amounting to 216% and 353% of fresh and dry mass, respectively, at 90 d age as compared to control irrigated every 5 days. Whereas, Mungbean plants watered every10 days exhibited suppression of growth, fresh and dry mass amounting to 54% and 60%, respectively, as compared to control irrigated every 5 days.

Plants irrigated every 10 days treated with biogin produced 136% and 225% of fresh and dry mass, respectively, as compared to control irrigated every 5 days (Sheteawi and Tawfik, 2007). Crop grown with no irrigation (I_o) or three irrigation (I_3) (vegetative +flowering + pod formation stage) produced the minimum thousand grain weight and were statistically at par with each other. However, during season II, control crop produced substantially lighter grains than other treatments (Malik *et al*., 2006). Boutraa and Sanders (2001) withheld water during the flowering and pod filling growth stages and found that yields were reduced, and that the yield component most affected was the number of pods per plant. Dapaah *et al*. (2000) show a 50% increase in seed yield with irrigation. Filling the root zone during our single irrigation event, a few days before the onset of flowering, we might well have provided green gram with sufficient water at a critical time. The same irrigation amounts applied several times in the season, a few Nielson and Nelson (1998) have shown that seed yield was reduced due to a reduction in the number of pods per plant and the number of seeds per pod.

Muchow (1985) reported that green gram is very sensitive to water stress during flowering and grain formation than vegetative stage. Irrigation applied at vegetative and flowering stage might have resulted in adequate and timely availability of nutrients, which boosted the crop development resulting in higher yields (Malik *et al*., 2006). De Costa *et al*. (1999) concluded that irrigation should extend illustrated by its higher harvest index under drought. Drought stress has the highest percentage (26%) when the usable areas on the earth are classified in view of stress factors (Blum, 1986). Mungbean or Green gram (*Vigna radiata* L. Wilczek) can be grown on a variety of soil and climatic conditions, as it is tolerant to drought. It is mostly grown under dry land farming system where erratic rains often fetch the crop under moisture stress (Azab, 1997). Muchow (1985) found that green gram had the highest yields under water deficit conditions. Green gram has evolved for survival in water limited conditions as it maintains a low stomata conductance regardless of water availability, possibly the result of a lower number of stomata on leaves. This seems related to its ability to yield better under water limited conditions than under conditions of abundant water is available, possibly by translocation more resources to seeds, as it is tolerant to drought. It is mostly grown under dry land farming system where erratic rains often fetch the crop under moisture stress (Azab, 1997). Oweis *et al*. (2005) studied the effect of water stress on growth and yield of a local variety (Hama 1) in northern Syria and they concluded that biomass and yield decreased and water use efficiency was reduced under water stress.

Haqqani and Pandey (1994) stated that Mungbean suffering water stress resulted in decreased seed yield, pod number, number of seeds/pod and 1000 seed weight. Flowers appeared earlier in plants irrigated every 5days than plants watered every 10 days. Plants of watered every 15 days, flowered later and produced fewer flowers than Mungbean watered every 15 days (Sheteawi and Tawfik, 2007). Water stress reduces the rate of photosynthesis and uptake of nutrient in green gram (Phogat *et al.,* 1984). Water stress also affects crop phenology, leaf area development, flowering, pod setting and finally results in low yield. Prasad *et al.,* (1989) found higher straw and grain yield of green gram with three irrigations as compared to one or no irrigation. Similarly, Sukhivinder *et al.,* (1990) found highest dry matter and grain yield of green gram when crop was irrigated thrice. Limited irrigation water availability poses the question as to when and how much to irrigate to achieve the optimum water uses efficiency. Thus, it is of paramount importance to determine the growth stage at which the green gram can respond to irrigation more efficiently. Due to the erratic nature of summer rains and variation in stored soil water at sowing, the crop is exposed to varying timing and severity of water deficit, which results in variability in grain yield.

The vegetative growth of Mungbean mostly ceases at the onset of the reproductive phase; the crop is able to produce second flushes of flowers if conditions are favorable (Ludlow and Muchow, 1990). Sheteawi and Tawfik (2007) noticed that total soluble carbohydrates, total soluble amino acids and proline generally increased in Mungbean plants watered every 10 days than for regime of 5 days, as response to water stress. Aktas *et al.* (2008) showed that amounts of IAA (except at the 4th level of leaf rolling), cytokinin, and ABA increased, while the level of GA_3 changed irregularly during leaf rolling. Amount of GA_3 increased at the 2nd level of leaf rolling but the increase was not significant. However, it was significantly decreased at the 3rd level of leaf rolling compared to the 1st level. At the 4th level of leaf rolling, GA_3 again increased and reached the value of the 1st level. In addition, amount of Abscisic acid did not significantly change up to the 3rd level of leaf rolling but it increased at the 4th level (Kutlu *et al.,* 2009). Therefore, the objective of this trails were to determine the best irrigation frequencies that match with optimal yield and chance for improving yield and yield quality by the aid of GA_3.

Materials and methods

This experiment was carried out during the Mungbean growing season 2010 at the research Field of field crops Department, College of Agriculture, Salahalddin University, located at Latitude, and Altitude. The objective of this investigation was to study the response of local Mungbean cultivar to varying irrigation frequencies and the possibility of varying rates of gibberellic acid (GA_3) foliar sprays in improving the drought resistance capability of this cultivar. Seeds of local Mungbean cultivar were purchased from the Agricultural Bureau in the Erbil city center. Split Plots arranged in Randomized Complete Block Design (Split-RCBD).

The main plots were irrigation frequencies (A): Where irrigating plants every 2 days represent (a_1), irrigating plants every 4 days (a_2), irrigating plant every 6 days (a_3), and irrigating plants every 8 days (a_4).Whereas, factor (B) was represented by GA_3 rates including 0mg.l^{-1} (b_1), 100mg.l^{-1}(b_2), and 200mg.l^{-1}(b_3). Subsequently 12 treatments were included in this investigation; each treatment was represented by 3 replicates. One replicate was included in a plot of 1m width and 1.2m length sown with 4 rows 30cm apart and 10cm intra plant space. Experiment land was plowed twice vertically and once more horizontally. Then the land was dissected to match the proposed design, where irrigation plots were separated from each other's by 4m to avoid water seepage among the main plots of irrigation. Seeds were sown on August 6th 2010, thereafter, germination watering was fulfilled immediately. Irrigation was proceeded according to the propose design throughout the growing season. Weeds were manually eradicated whenever they were observed in the field. In each irrigation time 20 mm of water was applied, and thus treatments of 2, 4, 6 and 8 days irrigation frequencies consumed 560, 280, 200, and 160mm respectively. Plants were sprayed by distilled water, 100 and 200mg.l^{-1} GA_3 on August 25th 2010 and repeated once more on September 5th 2010.

Plants were harvested on October 6th 2010, and then samples were brought to the laboratory for trait measurements. Days required for maturity, tiller number per plant, 1st fruiting node, leaf number per plant, inflorescence number per plant, pod number per plant, and seeds per pod were counted. Plant height (cm), internodes length (cm), and pod length (cm) were measured by roller. Plant fresh weights (g.m^{-2}), 1000 seeds (g) and dry seed yield (g.m^{-2}) and seeds weight per plant (g) were weighted by electrical metler balance of 2 decimal. Whereas, leaf area (cm2) was calculated by measuring the length breadth of the given leaf (Yoshida, 1972), by leaf area (cm^2) = Kemps constant for dicot leaves (k= 0.66) × length× breadth; leaf area index was calculated from total leaf area per plant divided on land area engaged by one plant; harvest index was calculated from seed yield divided on biomass yield. Finally, data were analyzed by computer statistical programmer, using Duncan's Multiple Range Test at $\alpha = 0.05$ probability level.

Appendix. Meteorological data during Mungbean growing season.

Recorded parameters		August	September	October	Means
Temperature C°	Max. T	45.4	42.7	36.4	41.5
	Min T.	38	34	21.1	31.03
	means	42.2	38.2	30.1	36.83
Relative Humidity (%)	Max.	33.2	51	94	59.4
	Min	17.8	34	40	30.6
	means	25.5	41.7	59.4	42.2
Wind Speed (km)	Max	6.2	3.5	4.4	4.7
	Min	1.4	0.8	0.1	0.76
	means	2.2	1.6	1.6	1.8
Rainfall incidences		0.0	0.0	0.0	0.0

Results and discussion

Influence of irrigation frequencies

Irrigating Mungbean plants every 8 days drastically reduced plant height (46.8%), internodes length (32.1%), number leaves per plant (64.3%), leaf area per plant 9158.5%), leaf area index (179.3%), inflorescence number per plant (119%) pod length (22.6%), pod number per plant (117%), seed number per pod (23.8), biomass yield (74.6%), yield (91.3%) and seed yield per plant (83.7%) (Tables 1 and 2). However, this treatment highly increased number first fruiting node (180.1%) and weight of 1000 seeds (11.5%).

Table 1. Growth characters of Mungbean in response to four irrigation types and three concentration levels of GA_3.

Treatments		Days for maturity	Plant height (cm)	Tillers no./ plant	Internod- length (cm)	1st fruiting node	Inflores. No./ plant	Pod length (cm)	No. of leaves/ plant	Leaf area (cm2/ plant)
Irrigation Type	2days	56.2b	49.4a	8.67	5.67a	1.1c	11.4a	5.64a	15.3a	838.24a
	4days	57.7ab	39.3b	8.33	4.08b	2.89a	8.11b	4.61b	11.3b	430.16b
	6days	59.5a	33.3c	7.67	4.58b	1.89b	7.89b	4.67b	10.1bc	413.82b
	8 days	58.4ab	33.6c	8.11	4.29b	3.11a	5.22c	4.60b	9.33c	324.21
GA3 mg.l-1	0	58.83	36.0b	8.00	4.29	2.33	7.75	4.85	11.08	521.37
	100	57.25	40.4a	8.33	4.93	2.00	8.83	5.03	11.50	521.73
	200	57.83	40.3a	8.25	4.76	2.42	7.92	4.77	12.00	561.72
Every 2 days	0	58.0ac	46.3b	8.33	5.30ac	1e	11ab	5.5ab	15.67a	827.43a
	100	56.0bc	49.6ab	9.0	5.52ab	1.33de	10b	5.6a	14.33a	874.83a
	200	54.67c	52.3a	8	6.19a	1e	13a	5.83a	16a	812.46a
Every 4 days	0	59ab	38.3cd	8	4.46bc	3b	7de	4.6bd	10.33bd	391.10e
	100	57.3bc	40c	8.67	4.73ad	2.33bd	10b	4.9ad	11.67b	473.6bc
	200	56.7bc	39.6cd	8.33	3.06e	3.33ab	7.33de	4.33cd	12b	425.9cd
Every 6 days	0	59.7ab	30ef	7.33	3.81ce	1.33de	8cd	5.2ac	10bd	514.53b
	100	57.7ac	36.3cd	8.33	4.84ad	1.67ce	9.67bc	4.53cd	11bc	416.9cd
	200	61.67a	33.6df	7.33	5.11ac	2.67bc	6ef	4.27cd	9.33cd	310.14e
Every 8 days	0	59ac	29.6f	8.33	3.59	4a	4.67	4.1d	8.33d	350.2de
	100	58ac	35.6ce	7.33	4.64bd	2.67bc	5.67ef	5.07ad	9cd	321.76e
	200	58.3ac	35.6ce	8.67	4.67ab	2.67bc	5.67ef	4.63cd	11.67b	298.42f

Irrigating plants every 8 days significantly reduced the detected parameters, as compared to that of watering every 4 days in terms of plant height (16.8%), number of leaves per plant (21.4%), leaf area per plant (32.6%) inflorescence number per plant (55.3%), pod number per plant (35.7%), biomass yield (34.9%), yield (41.3%) and seed yield per plant (31.9%). However, this treatment highly increased leaf area per plant (27.6%) number first fruiting node (7.6%). This treatment also reduced inflorescence number per plant (51.1) and pod number per plant (23.2%).However it increased number of first fruiting node (64.5%), as compared to that of irrigating plants every 6 days.

Irrigating plants every six days drastically reduced plant height (48.3%), internodes length (23.7%), number of leaves per plant (51.6%), leaf area per plant (102.5%) inflorescence number per plant (44.9), pod number per plant (76.1%), seed number per pod (23.8%), biomass yield (59.8%), yield (85.7%) and seed weights per plant (88%) and harvest index (17.7%) (Table 2). However, it highly increased days required for maturity (5.9%) and weight of 1000 seeds (12.6%), as compared with that of irrigation every 2 days. When a comparison was med between this treatment and that treatment of irrigation every 4 days similar trends were observed in the reduction of plant height (48.3%), first fruiting node (23.7%), biomass yield (23.5%), yield (37.1%) and seed weighs per plant (35%). Irrigating Mungbean plants every 4 days highly reduced plant height (25.7%), internodes length (38.9%), number of leaves per plant (35.3%), leaf area per plant (94.8%) pod number per plant (59.8%), seed number per pod (20%), biomass (29.3%), yield (35.4%) and weight of seeds per plant (39.2%).Weight of 1000 seeds, however, was highly increased (9.5%), as compared to two days irrigation treatment. Therefore, the best preformed plants was concomitant to treatment of irrigating Mungbean every two days which revealed the highest values in most investigated parameters. Treatments can be ordered due to their importance as below: 2days > 4days > 6days > 8days. Biomass yield and seed yield were linearly correlated to different irrigation frequencies. While, other traits were quadratically responded accept first fruiting node displayed cubic response (Table 3).

The priority of well irrigating Mungbean treatment in most detected traits was attributed to water availability for metabolic processes which are significantly hindered. Water stress reduces the rate of photosynthesis and uptake of nutrient in green gram (Phogat *et al.,* 1984). Water stress also affects crop phenology, leaf area development, flowering, pod setting and finally results in low yield. The vegetative growth of Mungbean mostly ceases at the onset of the reproductive phase; the crop is able to produce second flushes of flowers if conditions are favorable (Ludlow and Muchow, 1990).

Table 2. Yield and its components of Mungbean in response to four irrigation types and three concentration levels of GA_3.

Treatments		Leaf area index	Pods No. / plant	No. of seeds/ pod	1000-seed weight (gm)	Biomass yield/ m² (gm)	Seed yield / m² (gm)	Seed yield / plant (gm)	Harvest index (%)
Irrigation Type	2 days	2.71a	27.00a	8.67a	34.27b	418.50a	154.81a	4.08a	37.56a
	4 days	1.43b	16.89b	7.22b	37.54a	323.46b	114.30b	2.93b	34.78ab
	6 days	1.33b	15.33b	7.00b	38.62a	261.83c	83.36c	2.17c	31.91b
	8days	0.97b	12.44c	7.00b	38.24a	239.63c	80.89c	2.22c	34.02ab
GA_3 mg.l⁻¹	0	1.68	17.67ab	7.50	37.27	325.28a	114.17a	2.99	35.03a
	100	1.65	19.17a	7.50	36.65	293.93b	109.39ab	2.74	36.33a
	200	1.51	16.92b	7.42	37.59	313.36ab	101.46b	2.82	32.35b
Every 2 days	0	2.76a	27.67ab	8.67ab	34.2c	398.06b	159.86a	4.34a	40.50a
	100	2.67a	24.33b	8ac	34.13c	355.22c	138.67b	3.55ab	39.16ab
	200	2.71a	29a	9.33a	34.47bc	502.22a	165.91a	4.36a	33.02de
Every 4 days	0	1.30b	14.67eg	7bc	37.5a	399.89b	129.65b	3.20b	32.99de
	100	1.58ab	20c	8ac	36.73ac	329.94c	134.43b	3.23b	38.64ac
	200	1.42ab	16df	6.67bc	38.4a	240.56d	78.83c	2.36c	32.71de
Every 6 days	0	1.72ab	17.33ce	8ac	38.13a	252.89d	86.28c	2.26c	34.16ce
	100	1.26b	19.33cd	6.67bc	38.7a	262.78d	84.43c	2.04c	32.18de
	200	1.03b	9.33h	6.33c	38.97a	269.83d	79.37c	2.23c	29.38e
Every 8 days	0	1b	11gh	6.33c	39.23a	250.28d	80.90c	2.18c	32.46de
	100	1.07b	13fh	7.33ac	36.97ab	227.78d	80.04c	2.14c	35.33bd
	200	0.87b	13.67fh	7.67ac	38.53a	240.83d	81.73c	2.34c	34.29bd

Role of GA_3

Mash plants treated by (200 mg.l⁻¹ GA_3) substantially increased plant height (11.7%). However, treated plants highly reduced yield (12.5%) and harvest index (8.2%). However, other detected traits revealed non unequivocal differences with that of untreated plants. When a comparison was made with (100 mg.l⁻¹ GA_3) treated plants, reductions in pod number per plant (13.2%) and harvest index (12.3%) were observed. 200 mg.l⁻¹GA_3 treated plants tended to increase plant height (12%) and to reduce biomass yield (10.6%), as compared to untreated plants. Plant height, leaf number per plant, leaf area, leaf area index number of seeds per pod and seed yield were linearly related to irrigation frequencies. Whereas, other detected characteristics showed quadratic responses (Tables, 3 and 4). Gibberellic acid (GA_3) apparently proved the performance of leaf growth and reproductive organs through intermingling with other growth promoting hormones. In tobacco internodes, GA_{20}-oxidase is the major target for auxin from the shoot apex (Wolbang and Ross, 2001). It has been suggested that these increases in GA_1 and GA_4 are necessary for promoting inflorescence development.

Table 3. Regression analysis for the responses of mungbean growth and yield to irrigation frequencies.

Character	Regression equation	(R^2)
Days for maturity	Y= 63.331 – 2.503 X + 0.242 X^2	15
Plant height (cm)	Y = 22.331 + 7.163 X – 0.674 X^2	13.7
Tillers No./plant	Y = 6.81 + 0.623 X – 0.059 X^2	9.7
Internodes 'length (cm)	Y = 2.432 + 0.972 X – 0.091 X^2	11.8
1st fruiting node	Y = 2.444 + 3.87 X – 0.91 X^2 + 0.064 X^3	18.2
Inflorescence No./ plant	Y = 3.298 + 2 428 X – 0.254 X^2	17.6
No. of leaves/plant	Y = 7.228 + 1.757 X – 0.165 X^2	7.5
Leaf area (cm^2/ plant)	Y = 208.226 + 159.478 X – 17.833 X^2	20.5
Leaf area index	Y = 0.815 + 0.439 X – 0.5 X^2	9.7
Pod length (cm)	Y = 4.18 + 0.403 X – 0.046 X^2	11.8
Pods No. / plant	Y = 5.778 + 6.056 X – 0.639 X^2	22.2
No. of seeds/pod	Y = 6.558 + 0.531 X – 0.062 X^2	7.1
1000-seed weight (gm)	Y = 40.66 – 1.775 X + 0.19 X^2	15.4
Biomass yield/ m^2 (gm)	Y = 361. 363 – 11.082 X	8
Seed yield / m^2 (gm)	Y = 131.252 – 5.233 X	13
Seed yield / plant (gm)	Y = 2.06 + 0.433 X – 0.05 X^2	10.6
Harvest index (%)	Y = 30.633 + 2. 319 X – 0.273 X^2	17.7

Irrigation and GA_3 interaction

200 mg.l^{-1} GA_3 treated plants irrigated every 2 days appeared the most potent dual interaction treatment. Since it exhibited the highest values in terms of plant height (52.33 cm), internodes length (6.19), inflorescence number per plant (13), pod length 5.83 cm), pod number per plant (29), seed number per pod (9.33), biomass (502.22 g.m-2), yield (165.91 g. m^{-2}) and seed weights per plant (4.36 g) (Tables 1, 2). On the other hand all treatments regardless to GA_3 treatments were unequivocally reduced all detected parameters when irrigated every 8 days. In general abiotic adversity preponderated plant growth and thereby final yields. However, under moderate stresses, applying some compounds, particularly those that were proved to be reduced under such conditions would mitigate the negative effects of adversity on plants. Green gram (*V. radiata* L.) is one of the important short season grain legumes in the conventional farming system of tropical and temperate regions. It can be grown on a variety of soil and climatic conditions, as it is tolerant to drought. It is mostly grown under dry land farming system where erratic rains often fetch the crop under moisture stress (Malik *et al.,* 2006). They also postulated that Mungbean or green gram is a short-season summer-growing grain legume grown predominantly under dry land conditions throughout the tropics and subtropics. Due to the erratic nature of summer rains and variation in stored soil water at sowing, the crop is exposed to varying timing and severity of water deficit, which results in variability in grain yield. Kaneko *et al.* (2003) reported the role of GAs in mediating floral induction. In flowers, OsGA3ox1 and OsGA20ox1 genes are specifically expressed in tapetum cells of the anthers (Hedden and Thomas, 2006).

Table 4. Regression analysis for the responses of mungbean growth and yield to GA_3 rates.

Character	Regression equation	(R^2)
Days for maturity	Y= 58.833 – 0.027 X + 0.0001 X^2	7.7
Plant height (cm)	Y = 36.819 + 0.021 X	5.6
Tillers No./plant	Y = 8.069 + 0.001 X	1.7
Internodes' length (cm)	Y = 4.288 + 0.011 x – 0.00004 X^2	6.7
1st fruiting node	Y = 2.333 – 0.007 X + 0.00004 X^2	3
Inflorescence No./ plant	Y = 7.75 + 0.021 X – 0.0001 X^2	3.2
No. of leaves/plant	Y = 11.069 + 0.005 X	2
Leaf area (cm^2/ plant)	Y = 531.427 – 0.298 X	1.4
Leaf area index	Y = 1.699 – 0.0009 x	0.6
Pod length (cm)	Y = 4.85 + 0.004 X – 0.00002 X^2	2.5
Pods No. / plant	Y = 17.667 + 0.034 X – 0.0002 X^2	2.2
No. of seeds/pod	Y = 7.514 – 0.0004 X	0.1
1000-seed weight (gm)	Y = 37.267 – 0.014 X + 0.00008 X^2	3.1
Biomass yield/ m^2 (gm)	Y = 325.278 – 0.567 X + 0.003 X^2	2.3
Seed yield / m^2 (gm)	Y = 114.698 – 0.064 X	2.4
Seed yield / plant (gm)	Y = 2.993 – 0.004 X + 0.00002 X^2	1.4
Harvest index (%)	Y = 35.025 + 0.039 X – 0.0003 X^2	17.8

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