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Response of Growth Curve of Canola Genotypes to Use Different Concentration and Time of Application Gibberellin

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ABSTRACT

BACKGROUND: The crop needs growth regulators in order to complete the growth, because of its important role in improving biological activity, as many researches and studies indicated that the treatment of plants with a specific growth regulator leads to the improvement of the plant structure and the yield quality and the production of seeds.

OBJECTIVES: Current study was done to evaluate effect of Different level of Concentration and Time of Application Gibberellin on crop production and growth indices of Canola genotypes.

METHODS: This research was done via combined analysis split plot factorial experiment based on randomized complete blocks design with three replications along 2015-16 and 2016-17. The main factor included different level of canola genotype (Hyola401, RGS003, Jerry) and sub factors consisted different concentration of gibberellin hormone (0, 50 and 100 $mg.l^{-1}$) and different time of application of gibberellin hormone (Planting, vegetative phase before flowering, flowering until pod emergence).

RESULT: According result of analysis of variance effect of genotype, concentration and time of application gibberellin on studied traits was significant at 5% probability level (on seed yield at 1%) but interaction effect of treatments was not significant. Mean comparison result of different level of genotype indicated that maximum studied traits were noted for Hyola401 and minimum of those belonged to Jerry. As for Duncan classification made with respect to different level of Gibberellin Concentration maximum and minimum amount of studied traits belonged to 100 ppm and control. Between different levels of time of gibberellin application the maximum studied traits was observed in vegetative phase and the lowest ones were found in ripening phase.

CONCLUSION: Finally according result of current research application Hyola401 in amount of 100 ppm Gibberellin Concentration at Vegetative Phase had the highest amount of growth indices and seed yield and it can be advice to producers in studied region.

KEYWORDS: *Dry matter, Growth indices, Leaf area, Rapeseed, Seed yield.*

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1. BACKGROUND

Canola is one of the essential oily plants in Iran, which is cultivated widely in the country (Arabi Safari *et al*., 2018; Modhej *et al*., 2013). The yield of this plant is a complex trait that is controlled by multiple mechanisms. Its performance depends on the capacity of the variety, the weather conditions, the type of soil and agriculture management, the genetic and agronomic factors that determine the growth and development of the plant and thus the yield of the seed (Kuchtova *et al*., 1996: Koocheki and Khajehossini, 2008). Among the factors that affect the physiological, morphological and metabolic traits of the wheat plant are plant hormones or growth regulators, which through their influence on photosynthesis, respiration and the amounts of antioxidants in plant tissues and cells, cause regulation and coordination of processes and as a result increase plant performance (Toreti *et al*., 2019). Growth regulators are organic substances besides nutrients, synthesized in plants, causing alteration in their cellular metabolism. Synthesis of some plant hormones is adversely affected by environmental factors, which causes restriction on physiological processes of the plant and ultimately, limits their growth potential (Copur *et al*., 2010). GAs can stimulate stem and root elongation, leaf expansion, flowering, fruit senescence, seed germination, or dormancy (Hedden and Sponsel, 2015). Numerous phytohormones like abscisic acid (ABA), gibberellins (GAs), ethylene (ET), auxin (indole-3-acetic acid (IAA)), cytokinins (CKs), and brassinosteroids (BRs) that regulate plant development are also involved in controlling a variety of physiological and biological signaling and processes in the sessile plants. These cellular messengers may function as either adjacent or distant molecules from their positions of synthesis to respond against external stimuli or genetically automated progressive variations (Fahad *et al*., 2015). Ibrahim *et al*. (2007) by studied influence of some bioregulators (Gibberellic acid or GA, Indole acetic acid or IAA, benzyl adenine at the rate of 100 ppm or growth retardant ancymidol at the rate of 100 ppm) on agronomic traits of *Vicia faba* reported application of all the used treatments led to significant changes in the following items: plant height, average number of leaves, leaf area per plant and the dry weight of the shoot in both seasons. Application of benzyl adenine, IAA or ancymidol caused reduction in the flower abscission percentage and then producing the highest number of pod setting during the two seasons. All the used treatments of bioregulators caused marked changes in the seed yield and its components per plant (pod length, number of pods/plant, number and weight of seeds per pod as well as weight of 100 seeds).

2. OBJECTIVES

Current study was done to evaluate effect of Different level of Concentration and Time of Application Gibberellin on crop production and growth indices of Canola genotypes.

3. MATERIALS AND METHODS

3.1. Field and Treatments Information

This research was carried out to evaluate effect of different concentration and time of application of gibberellin hormone on canola genotypes production via combined analysis split plot factorial experiment based on randomized complete blocks design with three replications along two agronomic years (2015-16 and 2016-17). Place of research was located in Ahvaz city at longitude 48°40'E and latitude 31°20'N in Khuzestan province (Southwest of Iran). The main factor included different level of canola genotype (Hyola401, RGS003, Jerry) and sub factors consisted different concentration of gibberellin hormone (0, 50 and 100 $mg.l^{-1}$) and different time of application of gibberellin hormone (Planting, vegetative phase before flowering, flowering until pod emergence). This experiment had 27 plots. Each plot consisted of 8 lines with a distance of 30 cm and 5 meters length. The distance between the shrubs on every row was 5 cm.

3.2. Farm Management

Base fertilizers (50 $kg.ha^{-1}$ Nitrogen from urea, 100 $kg.ha^{-1}$ phosphorus from ammonium phosphate and 100 $kg.ha^{-1}$ potassium from potassium sulfate) were added to the soil based on soil tests and the recommendations of the Iranian Soil and Water Research Institute at the planting stage. Also 100 $kg.ha^{-1}$ Nitrogen was added to the soil at stem elongation phase. The light-disk harrow was used to mix the soil and the fertilizer after soil fertilization. The furrows were covered with soil. The seeds were planted 3 cm above the fertilizer. Physical and chemical properties of the soil are mentioned in table 1. To apply the first stage of gibberellin hormone before planting the seeds were soaked in three concentrations of the hormone overnight. The second stage of gibberellin application was done in the vegetative growth stage before flowering. The last stage of gibberellin application was done during the flowering to pod emergence stage.

Table 1. Physical and chemical properties of studied field

Soil depth (cm)	Acidity (pH)	Electrical conductivity ($ds.m^{-1}$)	Organic carbon (%)	Absorbable Phosphorus (ppm)	Absorbable potassium (ppm)
0-30	7.76	7.55	0.55	9.11	184
Clay (%)	**Silt (%)**	**Sand (%)**	**Soil texture**	**ρ_b ($gr.cm^{-3}$)**	**Fe (ppm)**
33	37	30	Clay	1.29	10.4

3.3. Measured Traits

In order to determine the yield two planting lines from each plot harvested and after the removal of marginal effect were carried to the laboratory and were placed in the oven at 75°C for 48 hours and after ensuring that the samples were completely dry, they were weighed and finally the total yield was measured. At flowering stage growth indices was measured. By measuring three factors including leaf area, leaf dry weight and total dry weight, the physiological parameters of growth including LAI, NAR, CGR and RGR were obtained using the following equations. To determine the leaf area of the linear relationship S= K. L.W was used in which S, L and W were the leaf area, L and W respectively, the maximum length and width of each leaf and K= 0.75 correction coefficient. The leaf area index was calculated from leaf area ratio to ground level. Crop growth rate, net assimilation rate and relative growth rate were measured according fallowing formula (Buttery, 1970; Enyi, 1962):

Equ.1. CGR ($gr.m^{-2}.day^{-1}$) = TDW_2-TDW_1/T_2-T_1

TDW_1= Primary dry weight (g), TDW_2= Secondary dry weight (gr)

T_1= initial sampling time, T_2= Secondary sampling time

Equ.2. NAR ($gr.m^{-2}.day^{-1}$) = CGR× $LnLA_2$-$LnLA_1$/LA_2-LA_1

CGR = Growth rate in grams per day per square meter

LA_1 = Initial leaf area, LA_2 = Secondary leaf area

Equ.3. RGR ($gr.gr^{-1}.day^{-1}$) = [Ln (TDW_2) – Ln (TDW_1)]/T_2-T_1

RGR= relative growth rate in gram per gram per day

3.4. Statistical Analysis

Analysis of variance was done via SAS (Ver.8) software. Mean comparison was done with Duncan test at 5% probability level.

4. RESULT AND DISCUSSION

4.1. *LAI* (*Leaf area index*)

According result of analysis of variance effect of genotype, concentration and Time of application Gibberellin on LAI was significant at 5% probability level but interaction effect of treatments was not significant (Table 2). Mean comparison result of different level of genotype indicated that maximum LAI (3.67) was noted for Hyola401 and minimum of that (2.91) belonged to Jerry (Table 3). As for Duncan classification made with respect to different level of Gibberellin Concentration maximum and minimum amount of LAI belonged to 100 ppm (3.69) and control (2.86) (Table 4). According result of mean comparison maximum of LAI (3.57) was obtained for Vegetative Phase and minimum of that (2.81) was for ripening phase (Table 5). Gibberellin acid led to increase leaf area index in soybeans. In general, gibberellin acid increases vegetative growth by affecting cellular processes such as cell division stimulation and cell elongation (Stuart and Jones, 1977). Maghsodi *et al*. (2014) stated in their research, as a result of the use of auxin hormone, the leaf area index and leaf surface durability of wheat increased and led to the delay of senescence in wheat leaves.

4.2. *TDM* (*Total dry matter*)

Result of analysis of variance revealed effect of genotype, concentration and Time of application Gibberellin on TDM was significant at 5% probability level but interaction effect of treatments was not significant (Table 2).

Table 2. Result analysis of variance of studied traits

S.O.V	df	LAI	TDM	CGR	RGR	NAR	Seed yield
Year	1	1.124^{ns}	180.15^{ns}	0.391^{ns}	0.995^{ns}	0.899^{ns}	379.65^{ns}
Replication × Year	4	0.725^{ns}	195.21^{ns}	0.610^{ns}	0.442^{ns}	0.998^{ns}	349.08^{ns}
Genotype (G)	2	87.122*	4957.77*	45.99*	11.992*	66.12*	9145.50**
G × Year	2	2.905^{ns}	154.82^{ns}	0.791^{ns}	0.542^{ns}	1.89^{ns}	310.02^{ns}
Ea		4.123	299.55	1.66	0.901	5.45	871.75
Gibberellin Concentration (GC)	2	75.92*	4899.12*	32.99*	18.82*	66.11*	7932.59*
GC × Year	2	0.511^{ns}	189.95^{ns}	0.031^{ns}	0.321^{ns}	0.2501^{ns}	296.00^{ns}
G × GC	4	0.301^{ns}	71.28^{ns}	0.699^{ns}	0.209^{ns}	0.145^{ns}	154.69^{ns}
Year × G × GC	4	0.745^{ns}	99.41^{ns}	0.99^{ns}	0.523^{ns}	0.3805^{ns}	202.71^{ns}
Time of Gibberellin application (TGA)	2	52.90*	2998.11*	16.99*	25.90*	52.77*	5944.34*
TGA × Year	2	0.303^{ns}	49.37^{ns}	0.195^{ns}	0.199^{ns}	0.991^{ns}	111.74^{ns}
TGA × G	4	0.119^{ns}	124.91^{ns}	0.301^{ns}	0.087^{ns}	0.045^{ns}	254.01^{ns}
TGA × G × Year	4	0.866^{ns}	52.66^{ns}	0.124^{ns}	0.666^{ns}	0.2905^{ns}	118.36^{ns}
GC × TGA	4	0.455^{ns}	143.63^{ns}	0.65^{ns}	0.331^{ns}	0.395^{ns}	299.63^{ns}
Year × GC × TGA	4	0.687^{ns}	123.77^{ns}	0.381^{ns}	0.551^{ns}	0.7105^{ns}	250.87^{ns}
G × GC × TGA	8	0.225^{ns}	109.32^{ns}	0.198^{ns}	0.121^{ns}	0.045^{ns}	230.77^{ns}
Year× G × GC × TGA	8	0.796^{ns}	124.11^{ns}	0.99^{ns}	0.449^{ns}	0.03502^{ns}	257.62^{ns}
Eb		1.112	205.99	0.82	0.99	3.295	327.14
CV (%)		7.75	8.11	7.25	5.15	6.65	6.32

$^{ns, *\ and\ **}$: no significant, significant at 5% and 1% of probability level, respectively.

Evaluation mean comparison result indicated in different genotype the maximum TDM (1230 gr.m^{-2}) was noted for Hyola401 and minimum of that (1010 gr.m^{-2}) belonged to Jerry (Table 3). Evaluation mean comparison result indicated in different level of Gibberellin Concentration maximum TDM (1210 gr.m^{-2}) was noted for 100 ppm and minimum of that (990 gr.m^{-2}) belonged to control treatment (Table 4). Assessment mean comparison result indicated in different Time of Gibberellin application the maximum TDM (1170 gr.m^{-2}) was noted for Vegetative Phase and minimum of that (952 gr.m^{-2}) belonged to Ripening Phase (Table 5). Mousavi *et al*. (2015) showed that the application of 15 ppm of auxin improved the physiological indices of growth and caused a 16.11% increase in dry matter yield compared to the control.

4.3. *CGR* (*Crop growth rate*)

According result of analysis of variance effect of genotype, concentration and Time of application Gibberellin on CGR was significant at 5% probability level but interaction effect of treatments was not significant (Table 2). Compare different genotype showed that the maximum and minimum amount of CGR belonged to Hyola401 (22.34 gr.m^{-2}.day^{-1}) and Jerry (16.85 gr.m^{-2}.day^{-1}) (Table 3). Evaluation mean comparison result of effect of different concentration of Gibberellin indicated maximum CGR (21.69 gr.m^{-2}.day^{-1}) was noted for 100 ppm and lowest one (15.98 gr.m^{-2}.day^{-1}) was for control (Table 4).

Table 3. Mean comparison effect of Genotypes on studied traits

Genotype	LAI	TDM ($gr.m^{-2}$)	CGR ($gr.m^{-2}.day^{-1}$)	NAR ($gr.m^{-2}.day^{-1}$)	RGR ($gr.gr^{-1}.day^{-1}$)	Seed yield ($kg.ha^{-1}$)
Hyola401	3.67a*	1230a	22.34a	6.56a	0.055a	2625a
RGS003	3.25ab	1100b	19.39b	5.11ab	0.045b	2498b
Jerry	2.91b	1010c	16.85c	4.07b	0.039c	2244c

*Similar letters in each column show non-significant difference at 5% probability level in Duncan test.

Between different levels of Time of Gibberellin application the maximum CGR (20.87 $gr.m^{-2}.day^{-1}$) was observed in Vegetative Phase and the lowest one (15.11 $gr.m^{-2}.day^{-1}$) was found in Ripening Phase (Table 5). Gibberellin is one of the plant growth-regulating hormones that have different effects on the growth and development of many plants during growth stages. The use of Gibberellin at high concentrations increases the growth of some of the plants (Abbasi *et al*., 2019). Gibberellin in addition to stimulating plant growth, increases the power of photosynthesis, leaf length growth, and tolerance to stress (Ashraf *et al*., 2002).

4.4. *NAR (Net assimilation rate)*

According result of analysis of variance effect of genotype, concentration and Time of application Gibberellin on NAR was significant at 5% probability level but interaction effect of treatments was not significant (Table 2). Mean comparison result of different level of genotype indicated that maximum NAR (6.56 $gr.m^{-2}.day^{-1}$) was noted for Hyola401 and minimum of that (4.07 $gr.m^{-2}.day^{-1}$) belonged to Jerry (Table 3). As for Duncan classification made with respect to different level of Gibberellin Concentration maximum and minimum amount of NAR belonged to 100 ppm (6.87 $gr.m^{-2}.day^{-1}$) and control (4.11 $gr.m^{-2}.day^{-1}$) (Table 4). According result of mean comparison maximum of NAR (6.71 $gr.m^{-2}.day^{-1}$) was obtained for Vegetative Phase and minimum of that (4.09 $gr.m^{-2}.day^{-1}$) was for ripening phase (Table 5). GAs have been commercially applied to control the vegetative growth of many horticultural crops. They might increase seed yield in firm-headed lettuce, enhance growth and sugar accumulation in sugar cane, accelerate peduncle elongation and bud development in artichokes and strawberry, etc. Recently, the application of exogenous gibberellic acid (GA3) has gained a renewed interest with the aim to promote plant growth, improve yield and increase tolerance to abiotic stresses (Maggio *et al*., 2010).

4.5. *RGR* (*Relative growth rate*)

Result of analysis of variance revealed effect of genotype, concentration and Time of application Gibberellin on RGR was significant at 5% probability level but interaction effect of treatments was not significant (Table 2). Evaluation mean comparison result indicated in different genotype the maximum RGR (0.055 $gr.gr^{-1}.day^{-1}$) was noted for Hyola401 and minimum of that (0.039 $gr.gr^{-1}.day^{-1}$) belonged to Jerry (Table 3).

Table 4. Mean comparison effect of Gibberellin Concentration on studied traits

Gibberellin Concentration	LAI	TDM ($gr.m^{-2}$)	CGR ($gr.m^{-2}.day^{-1}$)	NAR ($gr.m^{-2}.day^{-1}$)	RGR ($gr.gr^{-1}.day^{-1}$)	Seed yield ($kg.ha^{-1}$)
None use or control	2.86b	990c	15.98c	4.11b	0.035c	2196c
50 ppm	3.25ab	1075b	18.71b	5.44ab	0.042b	2448b
100 ppm	3.69a	1210a	21.69a	6.87a	0.053a	2575a

*Similar letters in each column show non-significant difference at 5% probability level in Duncan test.

Evaluation mean comparison result indicated in different level of Gibberellin Concentration the maximum RGR (0.053 $gr.gr^{-1}.day^{-1}$) was noted for 100 ppm and minimum of that (0.035 $gr.gr^{-1}.day^{-1}$) belonged to control treatment (Table 4). Assessment mean comparison result indicated in different Time of Gibberellin application the maximum RGR (0.058 $gr.gr^{-1}.day^{-1}$) was noted for Vegetative Phase and minimum of that (0.037 $gr.gr^{-1}.day^{-1}$) belonged to Ripening Phase (Table 5). The relative growth rate of crops during the plant life cycle has a decreasing trend. The reason for the downward trend in relative growth rate can be found in the accumulation of dry matter, which is mainly allocated to undifferentiated tissues. Also, the phenomenon of leaf shading on each other can be considered effective in this reduction (Sadi, 2016). Research on tomatoes has shown that leaf application of gibberellin increases photosynthesis, which can also be due to increased leaf area or increased photosynthetic rate per unit area of leaf area. Gibberellin has been shown to increase the activity of the enzyme ribulose bisphosphate carboxylase-oxygenase (Rubisco), which is the major enzyme of photosynthesis in plants (Fatek, 2019).

4.6. Seed yield

Result of analysis of variance revealed effect of genotype, concentration and Time of application Gibberellin on seed yield was significant at 1% and 5% probability level, respectively but interaction effect of treatments was not significant (Table 2). Compare different genotype showed that the maximum and minimum seed yield belonged to Hyola401 (2625 $kg.ha^{-1}$) and Jerry (2244 $kg.ha^{-1}$) (Table 3). Factors that control sink power and grain filling rate can control distribution of photosynthetic materials. Hormones can have significant effect on photosynthetic material transfer and grain filling through their effect on enzymatic activity and flexibility of target cells, so mentioned effect is more observed in high concentrations of gibberellin acid (Daglans, 2014). Evaluation mean comparison result of effect of different concentration of Gibberellin indicated maximum seed yield (2575 $kg.ha^{-1}$) was for 100 ppm and lowest one (2196 $kg.ha^{-1}$) belonged to control treatment (Table 4). Between different levels of Time of Gibberellin application maximum seed yield (2399 $kg.ha^{-1}$) was observed in Vegetative Phase and the lowest one (2152 $kg.ha^{-1}$) was found in Ripening Phase (Table 5).

Table 5. Mean comparison effect of Time of Gibberellin application on studied traits

Time of Gibberellin application	LAI	TDM ($gr.m^{-2}$)	CGR ($gr.m^{-2}.day^{-1}$)	NAR ($gr.m^{-2}.day^{-1}$)	RGR ($gr.gr^{-1}.day^{-1}$)	Seed yield ($kg.ha^{-1}$)
Seed planting	3.15b	1050b	18.02b	5.32ab	0.044b	2399b
Vegetative Phase	3.57a	1170a	20.87a	6.71a	0.058a	2520a
Ripening Phase	2.81c	952c	15.11c	4.09b	0.037c	2152c

*Similar letters in each column show non-significant difference at 5% probability level in Duncan test.

Gibberellin acid consumption in the period of vegetative growth compared to apply hormone at other growth stage had the highest grain filling rate. It seems that when the plant receives the gibberellin acid during the vegetative growth period, due to the positive effect that gibberellin on division and growth and expansion of various organs of the plant, the production of photosynthetic materials also increases, which leads to increased grain filling rate (Fitals, 2016). The increase in the number of pods per plant and the mass of 100 seeds can be related to the better production of the parameters responsible for the overall increase in seed yield. High levels of gibberellic acid have improved the grain yields of many legumes, including beans. The increase in grain yield in some cereals is mainly due to the increase in harvest coefficient, in other words, the plant does not produce excess dry matter, but allocates a large part of the dry matter to the economic yield of seed (Zianto, 2016).

5. CONCLUSION

Finally according result of current research application Hyola401 in amount of 100 ppm Gibberellin Concentration at Vegetative Phase had the highest amount of growth indices and seed yield and it can be advice to producers in studied region.

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FOOTNOTES

AUTHORS' CONTRIBUTION: All authors are equally involved.

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