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Study of Drought Stress and Plant Growth Promoting Rhizobacteria (PGPR) on Yield, Yield Components and Seed Oil Content of Different Cultivars and Species of Brassica Oilseed Rape

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ABSTRACT

Rapeseed is a new oilseed crop in Iran and its hectares has been currently expanding. Reproductive growth of the crop is exposed to water stress in many part of the country. In order to evaluation of yield, yield component and seed oil content of Brassica oilseed rape cultivars belong to Brassica napus, Brassica rapa and Brassica juncea species at stress and non stress locations with application of Pseudomonas strains , two experiment (including stress and non stress fields) were carried out on 2010-2011 growing season at Agriculture and Natural Resources Research Station of Torogh, Mashhad. Experimental design was factorial based on Randomized Competently Block Design (RCBD) . Results showed that drought stress caused to reduction of yield , oil content and yield components. Also the negative forceful effect of water deficit on yield components was regarding pod numbers. Violently final yield decreased(152.5%) in stress location. There were considerable difference between stress and non stress locations regarding yield, oil content and all yield components. Except number of lateral branches , significant difference at 1% probability level were found among cultivars in studied characteristics .It was concluded that inoculation treatment had better effects than either no inoculation (control) or co-inoculation but interestingly co-inoculation with Pseudomonas flourescens plus Pseudomonas putida was placed at the lowest rating in comparison with individual inoculation or no inculcation at surveyed traits.

Key Words: Rapeseed, drought stress, *Pseudomonas* strains, Yield, yield components, oil content

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INTRODUCTION

Iran is situated in semi-arid region and water shortage leads to emerge lots of problem in order to supply of drinking water and water requirements for crop production [1]. In order to UN report , damage of drought in Iran was exceeded to3.5 billion US$ so more than 1 million head of livestock and 3 million tons of wheat and barley were lost due to severe water crisis in year of 2000[2].

Three main mechanisms reduce crop yield by water stress: (i) reduced canopy absorption of photosynthetically active radiation, (ii) lessened radiation-use efficiency and (iii) reduced harvest index .The reproducibility of drought stress treatments is very cumbersome, which significantly impedes research on plant drought tolerance[3].Yield and drought resistance are controlled at separate genetic loci such breeding involves the identification and transfer of physiological traits responsible for drought resistance to high-yielding and agronomically acceptable cultivars[4] .

Rapeseed is an important oilseed crop in the agriculture systems of many arid and semiarid areas where its yield is often restricted by water deficit and high temperatures during the reproductive growth[5]. Brassica oil seed rape is generally considered to be more susceptible to drought than wheat. However, water deficiency produces different consequences according to the stage of the crop cycle and the magnitude of the deficiency. Rahnema and bakhshande [6] reported that the most rate of yield decrease was happened by spring irrigation cut off .Nielsen and nelson [7] reported lower yield was obtained from fewer branches per plant, pod per branches and smaller seed. Oil content in brassica oil seed rape fell down from 36.9 to 31.4 % when high temperature occurred during the post anthesis seed development . Final seed number and seed yield reduction was confirmed by high temperature effect during reproductive and ripening growth stages[8].

Plant growth – promoting bacteri (PGPB) are naturally soil bacteria that aggressively colonize plant roots and benefit plants by providing growth promotion. Inoculation of crop plants with certain of PGPB at an early stage of development improves biomass production through direct effects on root and shoot growth[9].

Specific strains of the Pseudomonas *fluorescens-putida* group have recently been used as seed inoculants on crop plants to promote growth and increase yield. The occurrence and activity of soil microorganisms are affected by a variety of environmental factors (e.g. soil type, nutrient abundance,pH,moisture content) as well as plant related factors such as species and age [10,11]so the interaction between associative PGPR and plants can be unstable[12].Several PGPR strains are also known to induce abiotic stress tolerance in some plants such as salt and drought stress in wheat [13] .

The aim of this work were to detect of drought stress influence on yield and yield component of brassica oilseed rape as well as to explore effects of inoculation with Pseudomonas strains on both boosting yield / yield components and tolerance to water deficit.

MATERIALS AND METHODS

The investigation were undertaken as tow simultaneous experiments (stress and non stress experiments) on 2010-2011 growing season at Agriculture and Natural Resources Research Station of Torogh, Mashhad in East-North of Iran (36˚ N , 59˚ E , 1003 as).Two research sites (stress and non stress fileds) were beside each other. This region has a semi-arid climate(annual rainfall 286 mm). The experimental design was factorial based on Randomized Competently Block Design (RCBD) with three replications in each experiment. Soil texture was silty loam(table2). The meteorological data of the region are representing in Table1.Drought stress experiment was done by cut off irrigation from stem elongation stage and at water stress free experiment (non stress treatment) , irrigation was applied to avoid drought stress and soil water in the 1 meter depth was kept above 50% of maximum available water during the all growing season. Studied factors in tow experiment were including

1- First treatment was Bacteria(Plant growth promoting rizobactria) : including
B0: no inoculation (control) , B1:co-inoculation(Pseudomonas *flourescens* 169+Pseudomonas *putida* 108) , B2: inoculation with Pseudomonas *flourescens* 169 and B3: inoculation with Pseudomonas *putida* 108

2- Second treatment was variety : including
Hayola401 and Hayola330 belong to Brassica *napus* , Parkland and Goldrush belong to B. *rapa* and BP18 and Landrace belong to B.*juncea*

Bacterial strains were used as seed treatments. Seeds of Brassica oilseed rape were surface-sterilized with 0.02% sodium hypochlorite for 2 min, and rinsed thoroughly in sterile distilled water. For inoculation seeds were coated with 40% gum arabic as an adhesive and rolled into the suspension of bacteria with perlit until uniformly coated density of bacteria in suspension were 1.025 CFU ($\times 10^9$ /ml) for Pseudomonas *putida* 108 and 1.25 CFU($\times 10^9$ /ml) for Pseudomonas *flourescens* 169 respectively. For better and precise results, each bacteria treatment in all replication were applied by individual worker.
In both experiments the sowing was done manually. The planting dates was on 27 October 2010. Each experimental plot included 4 planting rows with 8 m length and 30 cm within the rows . plant density was 90 plants per m^2 .

Stress filed harvested on 14 may 2011 and non stress filed harvested on 24 may 2011.The following measurements were done : seed yield (from $2m^2$ of central rows with ignoring border effect) , number of lateral branches and number of pods (were countered from 3 individual plants in each plot) , seed pods (were measured from 5 random pods from each plot) , 1000seed weight(seed counter was used to count the number of 1000 seed) . seed oil

contents were determined by Soxhlet methods[14]. Data were analyzed by SAS software and multiple comparisons was done through Least Significant Difference (LSD) test at 1% and 5% probability levels

Table 1:climate data of experimental were taken from of Mashhad Metrological station

month	Max temp (c˚)	Min temp (c˚)	Rainfall (mm)	Evaporation (mm)
Oct	24.9	9.6	0	149.2
Nov	19.9	4.7	8.6	85
Dec	17.7	1.2	0	6.9
Jan	10	-2.8	13.1	0
Feb	9.8	-0.8	41.3	0
Mar	10.6	0.2	22.4	0
Apr	22.3	7.6	10.1	160.3
May	30	15.5	15.4	224.9
Jun	34.4	19.4	6.4	317.3

Table2: some physical and chemical properties of experimental soil field at depth 0-30

Sand%	Silt%	Clay%	Texture	pH
33	46	21	Silty loam	7.8
EC (Ds/m)	Organic Carbon %	Total N%	Available P(ppm)	Available K(ppm)
1.07	0.56	0.047	15.6	190

RESULTS AND DISCUSSION

Number of lateral branch :

as it was interpreted from table 3, single effect of location was significant ($p<0.01$) and interaction effect of bacteria× variety and bacteria× variety ×location were highly significant ($p<0.01$).number of lateral branch in non stress location was 67.3% more than stress location(table 4).the highest and lowest twofold effect were observed in uninoculation(control) × Hayolla 401 and co-inculation (application of both bacteria) ×Goldrush respectively(table 5). number of lateral branch was intensely affected by threefold effect of uninoculation(control) ×Hayolla 401× non stress location at highest level and P.*fluorescens*× Goldrush × stress location at lowest level(table7a ,7b).lessening of lateral branches in water stress is also reported by other researchers[7,15,16]. Azizi and Arvin[17] claimed that lower numbers of fertile branches in Brassica oilseed rape cause to formation of lower pods and finally it lead to reduction of final yield. disorder of plant activities under water deficit cause to reduction or cessation of growth processes[18] thus notable decline of lateral branches at drought stress in this investigation was acceptable. it could be concluded from significant interaction effects of this trait , no inoculation(B0) had more superiority than other level of inculcation.

Number of pod:

Pods are the main components of final yield and total dry matter[19,20].Dipenbrock[21] stated that The number of pods per plant is decisive for seed yield; this trait is ultimately determined by the survival of branches, buds, flowers and young pods rather than by the potential number of flowers and pods.

Pod numbers varied considerably among locations, bacteria and varieties (table 3). also interaction effect of bacteria× variety and bacteria× variety ×location were significant ($p<0.01$). mean comparisons revealed that number of pod in non stress location eminently was 95.4% more than stress location(table 4).strongly effects of drought on lessening of pod numbers was confirmed with other studies[4,22,23]. the most number of pods was acquired at P.*fluorescence*(B2) and P.*putida*(B3) treatment and the least ones was obtained at combination of Pseudomonus (B1) treatment (table 4). It was also clear from the data (table5) twofold effect of B2 (P.*fluorescence*) × Parkland variety and threefold effect of B2(P.*fluorescence*)× Parkland × non stress location (table7b) were earned the most number of pods.in this study results proved that effect of individual inoculation on surveyed characteristics(either B2 or B3) were more than dual inoculation .interaction between plant growth promoting rhizobacteria (PGPR) may be antagonistic or synergistic , and the beneficial effects of such interactions could be exploited for economic grain [24,25].outcome of experiment presented that the highest and the lowest pod numbers were recorded by B.P18 (B.*juncea*) and Hyola 401(B.*napus*) cultivars respectively. Arvin [26] so long as comparison Brassica cultivars belong to B.*juncea*, B.*napus* and B.*rapa* species reported that BP18 (B.*juncea*) was obtained the highest number of pods so this result was in conformity with the result of this study.

Number of the seed per pod:

pod numbers is one of determinative parameters to yield formation[27,28]Yield per area is the product of population density, the number of pods per plant, the number of seeds per pod and the individual seed weight[29].

Results of combined analysis of variance indicated that (table3) there were considerable difference among cultivars and location at 1% probability level. also interaction effect of bacteria× variety was significant(table3). The mean comparison result also showed (table 4) that seed per pods in non stress location was 28% higher than stress location. results demonstrated that the number of seed per pod make change less than pod numbers at drought stress hence it was concluded selection or breeding of genotypes with high seeds per pod is cash in on tools under water stress conditions[8].Hyola330 and Hyola 401 were acquired the most seed per pod and BP18 was obtained the least of this trait (table4). Berry and Spink [30] announced that there were negative correlation between number of pod and seed per pod so this statement is in consistent with our finding regarding BP18 variety (table4).

Two fold effect of P.*putida* ×Hayola401 with 18 and combination of Pseudomonus strains (B1) × Landrace variety with 11 were achieved the highest and the lowest number of the seed per pods respectively (table 5). positive role of individual inoculation of bacteria in order to boost yield component was confirmed regarding seed per pod in this study .Naderifar and Daneshian [31] reported inoculation by PGPB lead to enhancement of seeds per pod in oilseed rape varieties.

1000 seed weight:

1000seed weight varied significantly among location, bacteria and variety (table 3) . mean comparison displayed(table 4) 1000 seed weight in non stress location (3.27gr) was higher than stress location (2.42gr). the highest effect of bacteria on this yield component were achieved by B3 and B2 treatment and B1 was situated at the lowest rating (table4) . synergistic effect of individual inoculation of bacteria and antagonistic influence of co-inoculation of both strains of Pseudomonus sp. regarding 1000 seed weight were absorb in this study . Plant growth promoting bacteria improved photosynthesis may be by increasing water and nutrients absorption leading to produce more assimilate and improve plant growth [31]. among cultivars , Hayola 401 with 3.55 gr and Hayola330 with 3.39 gr had the highest and Landrace with 2.21 gr had the lowest 1000 seed weight respectively(table 4). the most and the least significant twofold effect of 1000 seed weight was observed at non stress location × Hyola 401 and stress location × Parkland(table 6). decline of 1000 seed weight at stress condition in this study was in line with Vafa bakhsh et al [22] Hafeez et al[15] ,Nasri et al[32].

Oil content

Results of combined analysis of variance indicated that effect of location and variety were significant at 1% probability level regarding oil content (table3). as it was obtained from data (table4) oil percentage in non stress location (41.89%) was more than stress location (37.28%). among cultivars the highest and lowest oil percentage were(table4) related to Hayolla 330(41.5%) and Goldrush (38.27%). many of physiological and metabolic processes like as growth, development , synthesis of material and etc. in plant was decreased by drought stress [18].therefore reduction of oil content at water stress in this investigation was expectable. reports are available that strongly confirm lessening of oil percentage at drought stress [33]despite of considerable effect of bacteria on yield component , result showed that there was non significant effect of bacteria on oil content (table3).

Final yield

According to analysis of variance (Table 3), effect of location, variety and interaction effect of location × variety were significant about formation final yield. Based on revealed data (table4) final yield in non stress location (1351.85 $kg.ha^{-1}$) drastically was more than stress location (535.38 $kg.ha^{-1}$). Hayola 330 and Hayola 401 had the most and BP18 had the least seed yield (table4). Interaction effect of Hayola 330 × non stress location and Hayola 401× non stress location were significantly higher than BP18 × stress location (table6). superiority reason of Brassica Hayola hybrids rather than other cultivars could be found to have higher both of number of seed per pod and 1000 seed weight (table4). During the growth cycle, establishment of the stand, flower initiation, use of radiation and availability of assimilates for pod set and seed filling are decisive factors influencing yield[21]. Yield of Brassica napus , B.juncea and B.rapa decreased due to drought stress. the effect of drought strss is a function of genotype, intensity and duration of stress , weather conditions, growth and development stages on rapeseed [34]. it was clear to have direct effect of bacteria on yield components in this study so in spite of no observation found regarding direct influence of bacteria on final yield but it was interpreted that indirectly bacteria could raise final yield formation.

Table 3. The mean squares of ANOVA for yield components and yield via combined analysis of data

s.o.v	df	Branches per plant	Pods per plant	Seed per pods	1000 seed weight (g)	Oil percentage (%)	Seed yield (kg.ha^{-1})
L	1	646.006944*	129300.173*	473.062**	25.999**	767.382**	23998323.09*
Eroor1	4	44.111111**	6729.888**	9.5138ns	0.119ns	35.854**	1241178.53**
B	3	5.192129ns	4572.858**	12.562ns	0.165*	4.041ns	84719.6ns
B*L	3	11.17361ns	1379.729ns	22.1921ns	0.017ns	1.175ns	164776.6ns
V	5	19.92361ns	9918.929**	32.923**	8.093**	36.531**	1835880.5**
V*L	5	6.690277ns	2227.140ns	8.279ns	0.188**	7.092ns	393052.7**
B*V*L	15	21.74583**	3389.295**	13.0331ns	0.0165ns	2.714ns	72258.08ns
B*V	15	21.14212**	2589.536**	18.801*	0.0352ns	3.248ns	112661.54ns
Error2	92	8.72705	1080.555	9.81	0.0487	3.946	98133.83
c.v(%)		35.12	35.43	21.24	7.75	5.01	33.19

*note:**: p<0.01; *: p<0.05; ns: non significant - abbreviation :Location(L), Bacteria(B) and Variety(V)*

Table4. Individual effects of Location, bacteria and Variety

Treatment	Branches per plant	Pods per plant	Seed per pods	1000 seed weight (g)	Oil percentage (%)	Seed yield (kg.ha^{-1})
L1	6.2b	62.8b	12.9b	2.4b	37.28b	535.38b
L2	10.5a	122.7a	16.5a	3.2a	41.89a	1351.85a
B0	8.8a	93.05a	14.69a	2.8a	39.301a	942.66a
B1	8.1a	77b	14.02a	2.7b	39.92a	884.27a
B2	8.5a	103a	14.77a	2.8a	39.82a	1003.09a
B3	8.05a	98.02a	15.47a	2.8a	39.303a	944.44a
V1	8.41abc	59.79d	15.83a	3.5a	39.78b	1083.45b
V2	7.83bc	100.2ab	16.33a	3.3b	41.5a	1381.95a
V3	8.91ab	105ab	13.62b	2.2e	40.23b	917.83bc
V4	7.12c	78.95c	15.04ab	3.09c	38.27c	877.09c
V5	9.79a	116.708a	13.61b	2.5d	38.27c	546.3d
V6	8.37abc	95.95bc	14b	2.21e	39.46b	855.09c

note: Column means followed by the same letter are not significantly different at 5% probability level using least significant difference (LSD) – abbreviation:L1: stress location, L2:non stress location, B0: non inoculation ,B1: co-inoculation (Pseudomonas fluorescens and Pseudomonas putida) , B2: inoculation with Pseudomonas fluorescens , B3: inoculation with Pseudomonas putida,V1:Hayola401,V2:Hayola330,V3:Parkland,V4:Goldrush,V5:BP18, V6:Landrace

Table5. Interaction effect of Bacteria × Variety (B×V)

TREATMENT	Branches per plant	Pods per plant	Seed per pods	1000 seed weight (g)	Oil percentage (%)	Seed yield (kg.ha^{-1})
b0v1	12a	70.83f-i	13.33c-g	3.6517a	40.182a-f	1134.7a
b0v2	9.16a-f	115.5a-e	16.66abc	3.4233a	41.622ab	1296.3a
b0v3	7.66defg	80.17e-j	16.5abc	2.2557a	39.388b-h	907.4a
b0v4	7.167defg	61.5jhi	16.167abc	3.1163a	37.635hg	855.6a
b0v5	10a-e	140.67ab	12efg	2.572a	38.105fgh	745.4a
b0v6	7.167defg	89.67d-i	13.5c-g	2.116a	38.88c-h	716.7a
b1v1	7.83defg	47.5j	15.83abcd	3.519a	40.247a-f	1032.4a
b1v2	6.667efg	70f-i	15.66abcd	3.246a	41.853a	1175.9a
b1v3	8c-g	98.67c-h	12.33defg	2.285a	41.85852a	1092.6a
b1v4	5.833g	47.5j	14.83a-f	2.917a	38.207fgh	861.1a
b1v5	9.66a-e	103.17a-e	14.5a-g	2.4183a	37.553h	300.9a
b1v6	11.33abc	94.67c-h	11g	2.1033a	39.858a-g	842.6a
b2v1	8c-g	67ghij	16.15abc	3.53a	39.145c-h	1134.3a
b2v2	7.33defg	100.33c-g	17.33ab	3.4433a	41.627ab	1523.1a
b2v3	9.83a-e	142.17a	11.66fg	2.3503a	40.617abcd	861.1a
b2v4	6.667efg	83.67e-j	13.16c-g	3.1417a	38.207efgh	986.1a
b2v5	11.5ab	130.83abc	14.83a-f	2.5222a	38.742c-h	495.4a
b2v6	8.16b-f	94c-h	15.5a-f	2.351a	40.51a-e	1018.5a
b3v1	5.833fg	53.33ij	18a	3.533a	39.562b-h	1032.4a
b3v2	8.16b-g	115a-e	15.66abcd	3.4567a	40.922abc	1532.4a
b3v3	10.16abcd	99c-h	14b-f	2.2217a	39.1d-h	810.2a

b3v4	9.33a-e	123.17abcd	16abc	3.2223a	38.908c-h	805.6a
b3v5	8c-g	92.17d-h	13.16c-g	2.624a	38.7c-h	643.5a
b3v6	6.833defg	105.5a-f	16abc	2.2983a	38.335d-h	842.6a

note: Column means followed by the same letter are not significantly different at 5% probability level using least significant difference (LSD) – abbreviation:L1: stress location, L2:non stress location, B0: non inoculation ,B1: co-inoculation (Pseudomonas fluorescens and Pseudomonas putida) , B2: inoculation with Pseudomonas fluorescens , B3: inoculation with Pseudomonas putida,V1:Hayola401,V2:Hayola330,V3:Parkland,V4:Goldrush,V5:BP18, V6:Landrace

Table6. Interaction effect of Variety× Location (V×L)

TREATMENT	Branches per plant	Pods per plant	Seed per pods	1000 seed weight (g)	Oil percentage (%)	Seed yield (kg.ha^{-1})
Variety* Location						
V1L1	5.417a	41.92a	13.917a	3.062c	37.19a	537.3ef
V2L1	5.417a	56.92a	14.167a	2.835de	38.55a	870.4d
V3L1	6.833a	66a	12.5a	1.888h	37.46a	537ef
V4L1	5.416a	50.92a	12.5a	2.701ef	36.27a	402.3f
V5L1	7.833a	94.08a	11.583a	2.132g	36.72a	340.3f
V6L1	6.833a	67a	12.91a	1.911h	37.47a	525ef
V1L2	11.417a	77.67a	17.75a	4.055a	42.37a	1629.6b
V2L2	10.25a	143.5a	18.8a	3.949a	44.45a	1893.5a
V3L2	11a	144a	14.75a	2.667ef	43.01a	1298.6c
V4L2	8.833a	107a	17.583a	3.497b	41.46a	1351.9c
V5L2	11.75a	139.33a	15.667a	2.936cd	39.82a	752.3de
V6L2	9.917a	124.92a	15.08a	2.523f	41.46a	1185.2c

note: Column means followed by the same letter are not significantly different at 5% probability level using least significant difference (LSD) – abbreviation:L1: stress location, L2:non stress location, B0: non inoculation ,B1: co-inoculation (Pseudomonas fluorescens and Pseudomonas putida) , B2: inoculation with Pseudomonas fluorescens , B3: inoculation with Pseudomonas putida,V1:Hayola401,V2:Hayola330,V3:Parkland,V4:Goldrush,V5:BP18, V6:Landrace

Table7a. Interaction effect of Bacteri × Variety× Location(B×V×L)

TREATMENT	Branches per plant	Pods per plant	Seed per pods	1000 seed weight (g)	Oil percentage (%)	Seed yield (kg.ha^{-1})
b0v1L1	6.000hijk	45.33nop	11.000ijkl	3.1267ef	37.090m-r	500.9n-r
b0v2L1	5.000jk	67.00l-p	15.333b-j	2.8733e-k	39.837e-n	944.4f-m
b0v3L1	7.000g-k	78.33i-p	15.000c-j	1.8700pqr	36.467opqr	490.8n-r
b0v4L1	7.333f-k	51.00mnop	14.333d-j	2.6593i-m	36.493opqr	516.7n-r
b0v5L1	7.000g-k	84.67h-o	11.667h-l	2.1773nop	37.023n-r	361.1pqr
b0v6L1	6.667g-k	58.67l-p	12.333g-l	1.7287r	36.603opqr	303.7qr
b1v1L1	5.667ijk	37.00op	13.000f-l	3.0367efg	37.917k-r	611.1m-r
b1v2L1	6.667g-k	68.33k-p	14.333d-j	2.7667g-m	37.970j-r	842.6h-p
b1v3L1	5.333ijk	57.33l-p	10.667jkl	1.8967opqr	39.533e-o	824.1h-p
b1v4L1	5.000jk	34.33op	11.667h-l	2.6233jklm	36.017pqr	444.5n-r
b1v5L1	7.333f-k	68.67j-p	8.667l	2.0400opqr	35.950qr	148.2r
b1v6L1	6.667g-k	63.00l-p	9.000kl	1.7433qr	38.116i-r	583.3n-r
b2v1L1	5.000jk	48.67mnop	16.333a-h	3.0633efg	36.560opqr	537.0n-r
b2v2L1	4.667jk	48.33mnop	14.667d-j	2.8333f-l	37.783k-r	814.8h-p
b2v3L1	6.000hijk	71.00j-p	10.667jkl	1.9707opqr	37.310l-r	425.9opqr
b2v4L1	2.667k	27.67p	12.333g-l	2.7100g-m	35.983pqr	425.9opqr
b2v5L1	9.000d-j	121.67d-j	15.000c-j	2.0707opqr	37.190l-r	351.9pqr
b2v6L1	8.000f-j	78.00i-p	13.667e-l	2.0987opq	39.350f-o	759.2kq
b3v1L1	5.000jk	36.67op	15.333b-j	3.0233efgh	37.223l-r	500.0n-r
b3v2L1	5.333ijk	44.00nop	12.333g-l	2.8667e-k	38.643h-r	879.7go
b3v3L1	9.000d-j	57.33l-p	13.667e-l	1.8167qr	36.537opqr	407.4opqr
b3v4L1	6.667g-k	90.67g-n	11.667h-l	2.8133f-m	36.603opqr	222.2r
b3v5L1	8.000f-j	101.33f-m	11.000ijkl	2.2400no	36.740n-r	500.0n-r
b3v6L1	6.000hijk	68.33k-p	16.667a-h	2.0733opqr	35.787r	453.7n-r

note: Column means followed by the same letter are not significantly different at 5% probability level using least significant difference (LSD) – abbreviation:L1: stress location, L2:non stress location, B0: non inoculation ,B1: co-inoculation (Pseudomonas fluorescens and Pseudomonas putida) , B2: inoculation with Pseudomonas fluorescens

, B3: inoculation with Pseudomonas putida,V1:Hayola401,V2:Hayola330,V3:Parkland,V4:Goldrush,V5:BP18, V6:Landrace

Table7b. Interaction effect of Bacteri × Variety× Location(B×V×L)

TREATMENT	Branches per plant	Pods per plant	Seed per pods	1000 seed weight (g)	Oil percentage (%)	Seed yield ($kg.ha^{-1}$)
b0v1L2	18.000a	96.33g-n	15.667a-j	4.1767a	43.273abcd	1768.5ab
b0v2L2	13.333abcd	164.00abcd	18.000a-f	3.9733abc	43.407abcd	1648.1bcd
b0v3L2	8.333e-j	82.00i-o	18.000a-f	2.6413jklm	42.310b-f	1324.1b-h
b0v4L2	7.000g-k	72.00j-p	18.000a-f	3.5733d	38.777g-r	1194.4d-k
b0v5L2	13.000bcde	196.67ab	12.333g-l	2.9667e-j	39.187f-p	1129.6e-l
b0v6L2	7.667f-j	120.67d-k	14.667d-j	2.5033lmn	41.157c-j	1129.6e-l
b1v1L2	10.000c-i	50.00l-p	18.667a-e	4.0013ab	42.577a-e	1453.7bcde
b1v2L2	6.667g-k	71.67j-p	17.000a-g	3.7253bcd	45.733a	1509.3bcde
b1v3L2	10.667c-h	140.00c-g	14.000d-k	2.6733h-m	44.170abc	1361.1b-g
b1v4L2	5.667ijk	60.67l-p	18.000a-f	3.2107e	40.397d-l	1277.8b-j
b1v5L2	12.000b-f	137.67c-h	20.333ab	2.7967f-m	39.157f-q	453.7n-r
b1v6L2	16.000ab	126.33[illegible]	13.000f-l	2.4633mn	41.557c-h	1101.9e-m
b2v1L2	11.000c-g	85.33h-o	16.000a-i	4.0000ab	41.730c-h	1731.5abc
b2v2L2	10.000c-i	152.33b-f	20.000abc	4.0533ab	45.470ab	2231.5a
b2v3L2	13.667abcd	213.33a	12.667g-l	2.7300g-m	43.923abc	1296.3b-i
b2v4L2	10.667c-h	139.67c-g	14.000d-k	3.5733d	40.687d-k	1546.3bcde
b2v5L2	14.000abc	140.00c-g	14.667d-j	2.9733e-j	40.293d-m	638.9l-r
b2v6L2	8.333e-j	110.0e-l	17.333a-g	2.6033klm	41.670c-h	1277.8b-j
b3v1L2	6.667g-k	70.00j-p	20.667a	4.0433ab	41.900c-g	1564.8bcde
b3v2L2	11.000c-g	186.00abc	19.000abcd	4.0467ab	43.200abcd	2185.2a
b3v3L2	11.333b-g	140.67c-g	14.333d-j	2.6267jklm	41.663c-h	1212.9d-k
b3v4L2	12.000b-f	155.67bcde	20.333ab	3.6313cd	41.213c-i	1388.9b-f
b3v5L2	8.000f-j	83.00i-o	15.333b-j	3.0080e-i	40.660d-k	787.0j-q
b3v6L2	7.667f-j	142.67c-g	15.333b-j	2.5233klmn	41.467c-h	1231.5c-k

note: Column means followed by the same letter are not significantly different at 5% probability level using least significant difference (LSD) – abbreviation:L1: stress location, L2:non stress location, B0: non inoculation ,B1: co-inoculation (Pseudomonas fluorescens and Pseudomonas putida) , B2: inoculation with Pseudomonas fluorescens , B3: inoculation with Pseudomonas putida,V1:Hayola401,V2:Hayola330,V3:Parkland,V4:Goldrush,V5:BP18, V6:Landrace

CONCLUSION

They were concluded from the present study

1- Drought stress drastically lessened seed yield and this decreasing final yield was special palpable by reduction of pod per plant more than other yield components and seed per pod less change than others . Therefore seed per pod seems to be beneficial tool for selection variety under drought stress.

2- individual inoculation of Brassica oilseed rape with either Pseudomonas *fluorescens* or Pseudomonas *putida* showed significant influence on yield formation and mitigation of drought stress but interestingly co-inoculation had antagonistic effect so its suggestible that inoculation or even no inoculation (control) give better result than co-inoculation regarding oilseed rape .

3- Brassica Hayola hybrids due to have a better yield components result to formation better final seed yield thus application of these cultivars with inoculation of Pseudomonas sp. particularly in non stress condition is worthwhile.

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