Nile Valley University
Nile Journal for Agricultural Sciences
(ISSN: 1858 - 7046)
Issue 01, 2016
http://www.nilevalley.edu.sd

Research paper

The Performance of Nine Common Bean (*Phaseolus vulgaris* L.) Genotypes under Three Sowing Dates, in River Nile State

Gamal E. Khalifa[a], Ali E. Eljack[b], Osman M. Elamin[b] and Elsadig S. Mohamed[c]

[a] *Hudeiba Research Station, Eddamer, Sudan*
[b] *University of Gezira, Faculty of Agricultural Sciences, Wad Medani, Sudan*
[c] *Agricultural Research Corporation, Wad Medani, Sudan*
Corresponding author: gamalhrs@yahoo.com

ABSTRACT

The performance of nine common bean genotypes (*Phaseolus vulgaris* L.) was investigated under sowing dates. The field experiments were conducted during winter season of 2003/04 and 2005/06 in Hudeiba Research Station Experimental Farm, Eddamer, River Nile State. The objective of the study is to identify the most tolerant genotypes to heat stress. Nine genotypes of different seed sizes; small seeded (Basabeer, DB 190-74-1 and UBR(92)25-2), medium seeded (Giza-3, Bellenber-1 and COWU-3-94-9) and large seeded (Ibarya, Turki-2 and S/Hashim/98), were tested at three sowing dates; early (SD1, 1st Oct.), optimum (SD2, 30 Oct.) and late (SD3, 30 Nov.). A split- plot design with three replications was used to execute the experiments; sowing dates were assigned to the main plots and genotypes to the subplots. Results showed that sowing date treatments significantly affected the reproductive traits of common bean genotypes. The highest values of yield under stress (early planting to yield under non-stress (YSD1/YSD2) conditions were obtained with the small (59 %) and medium (82 %) seeded genotypes. However, the highest values of yield under stress (late planting) to yield under non-stress (YSD3/YSD2) were obtained with the large (53 %) and the medium (56 %) seeded genotypes. The highest value of geometric mean productivity (1591 kg) was obtained with the genotype Giza 3. The highest values of geometric mean productivity at SD1 (1842 kg and 1734 kg) and SD3 (1338 kg and 1530 kg) were obtained by Basabeer and Giza3 genotypes, respectively. The genotypes Basabeer and Giza3 are adapted to favorable conditions. Bellenber-1 is the most tolerant under heat stress conditions at both early and terminal heat stress and can be used in breeding program.

Keywords: *Common bean, genotypes, heat stress, sowing dates, Sudan.*

استجابة تسعة سلالات من الفاصوليا لثلاثة مواعيد للزراعة تحت ظروف ولاية نهر النيل

جمال الخير خليفة[1]، على الامين الجاك[2]، عثمان محمد الامين[2] والصادق سليمان محمد[3]

[1] محطة بحوث الحديبة، الدامر، [2] كلية العلوم الزراعية، جامعة الجزيرة، ودمدنى، [3] هيئة البحوث الزراعية، ودمدنى

تسعة من سلالات الفاصوليا تم تجريبها في ثلاثة مواعيد مختلفة للزراعة خلال فصل الشتاء في موسمي 2003/04 و 2005/06 بمزرعة محطة بحوث الحديبة بالدامر. وتهدف الدراسة لمعرفة اكثر الاصناف مقاومة لظروف الاجهاد الحرارى وصنفت الاصناف لصغيرة الحبة ومتوسطة الحبة وكبيرة الحبة. وقد اختبر اداؤها في ثلاثة مواعيد للزراعة: مبكرة في الاول من اكتوبر ومثالية في الثلاثين من اكتوبر ومتأخرة في الثلاثين من نوفمبر. استخدم تصميم القطع المنشقة بثلاثة مكررات لتنفيذ هذه التجربة بتوزيع مواعيد الزراعة على القطاعات (الاحواض) الرئيسة والسلالات المختلفة على القطاعات (الاحواض) الفرعية. اثبتت التجربة تأثير مواعيد الزراعة على القراءات المختلفة معنوياً. اعلى قيمة للإنتاجية تحت الاجهاد الناتج عن الزراعة المبكرة مقسومة على الانتاجية دون اجهاد حرارى (المواعيد المثلى) نتجت عن السلالات صغيرة الحبة (59 %) ومتوسطة الحبة (82 %). كما وأن اعلى قيمة للإنتاجية تحت الاجهاد الحرارى الناتج عن الزراعة المتأخرة مقسومة على الاخرى (دون اجهاد حرارى) نتجت عن السلالات كبيرة الحبة (53 %) ومتوسطة الحبة (65 %). السلالة جيزة 3 احرزت القيمة الاعلى للمتوسط الهندسي للإنتاجية (159 كجم). كما احرزت السلالات بسابير وجيزة3 القيمة الاعلى للمتوسط الهندسي للإنتاجية (1842 و1734 كجم للزراعة المبكرة و1338 و1530 كجم للزراعة المتأخرة) على التوالي. اثبتت السلالات بسابير وجيزة3 موائمة للظروف المثالية للإنتاج بينما السلالة بنلر 1 كانت الاكثر موائمة لظروف الاجهاد الحرارى لكل من الزراعات المبكرة والمتأخرة على السواء وبالتالي فيمكن اخضاعها لبرامج تربية.

Introduction

In Sudan, common bean (*Phaseolus vulgaris* L.) is normally cultivated under residual soil moisture in basins and islands after recession of the Nile flood. In addition, appreciable areas are also grown under irrigation. Average areas grown with this crop in recent years reached 15000 ha with an average productivity ranging between 0.5 and 1 ton/ha. However, this yield level is much less than the yield potential of this crop. The major producing areas of common bean in the north of Sudan are Shendi and Berber, where more than 90% of the crop is produced. The common bean is grown during the winter season which is characterized by having warm and short and sometimes even hot spells. Heat and drought are considered as the main limiting factors of bean production in east, central and southern Africa causing losses of more than 395000 tons each year. Moisture and heat stress, in conjunction with biotic stresses especially diseases and pests, act as main factors responsible for low productivity of common bean. These multiple constraints often act concurrently with considerably negative effects on the quantity and quality of crop production (Amede *et al.*, 2001). The rate of temperature change, and the duration and degree of high temperatures, all contribute to the intensity of heat stress. Therefore, the objective of this study is to identify the most tolerant bean genotypes to early and terminal heat stresses.

Materials and Methods

The experiment was carried out during the three consecutive winter seasons (2003/04 and 2005/06) at Hudeiba Research Station farm, River Nile State, Sudan. The crop of the experiment in season 2004/05 showed symptoms of diseases and complete sudden loss was occurred. The soil of the experimental site was classified as Karima series, with about 47 % clay, 11 % silt and 42 % sand. Maximum and minimum temperatures for the two seasons (2003/04 and 2005/06) are shown in Figure (1, A and B). The genotypes and sowing dates were arranged in split-plot design with three replications. Nine genotypes were used in this study and grouped according to their seed size (small<24 g/100 seed: Basabeer, DB 190-74-1 and UBR (92) 25-2), medium (25-35 g/100 seed: Giza-3, Bellenber-1 and COWU-3-94-9) and large (>39g/100 seed: Ibarya, Turki-2 and S/Hashim/98). To study the effect of temperature on the above-mentioned nine common bean genotypes, three sowing dates were used: early planting (SD1, 1st October), optimum or recommended planting date (SD2, 30 October) and late planting (SD3, 30 November). Sowing dates were randomly assigned to the main plots and genotypes to the subplots. The sub-plot size was 1.2 m x 6 m, consisted of two rows. Sowing was on both sides of the ridge at a rate of two seeds per hole with intra row spacing of 20 cm between holes. Crops were kept weed-free by hand hoeing every week in all experimental plots. Data were collected from five random plants taken from each row per sub-plot. Number of pods per plant, number of seeds per pod, 100-seed weight (g) and seed yield (kg/ha) was determined for each sub-plot.

Heat susceptibility index of Fisher and Maurer (1978) was determined for each genotype, based on data of seed yield:

HSI= (YSDn-YSDs)/ (YSDn (1- YSDs /YSDn)

Where:

YSDs and YSDn = mean yields of all genotypes evaluated under SD1, SD3 (Stress) and SD2 (recommended sowing date), respectively.

(YSDn-YSDs) = relative yield reduction due to stress.

1 - YSds/YSdn = heat intensity index (relative yield reduction over all genotypes in the environment).

Values of HSI < 1 denote below average heat susceptibility (= above average heat tolerance), an average reaction is defined by HSI = 1, and values of HSI>1 describe above heat susceptibly (= below average heat tolerance).

Geometric mean of productivity (GMP) is measured as square root of yield under stress to yield under non-stress conditions as described by Fernandez (1993):

$$GMP = (YSDs \times YSDn)^{0.5}$$

Results and Discussion

Results presented in Tables 1, 2 and 3 showed that number of pods per plant were reduced at the early sowing (SD1) which may be reasonably explained by the relatively high temperatures prevailing during fertilization and pod setting stage. The genotypes Basabeer and Giza3 were not affected by the early sowing as they produced similar seed weights to that of the optimum one. Sensitivity of the reproductive stages in common bean to temperatures has been reported by Weaver *et al.*, 1985, Monterroso and Wien, 1990 and Konsens *et al.*, 1991. Stages sensitive to high temperatures include flower bud formation, flowering, pollen formation and function, fertilization, and pod and seed set. Konsens *et al.* (1991) indicated that heat- induced abscission of flower buds before anthesis could be due to decreased carbohydrates level or translocation constraints. It appears that pollen grains are more sensitive to high temperatures than female reproductive structures (Dickson and Botteger, 1984 and Monterroso and Wien, 1990). Furthermore, Paulsen (1974) stated that high temperatures are particularly detrimental, because they affect crops directly by impairing physiological processes and indirectly by altering plant-water relations.

In this study, most of the genotypes gave heavier seed weights at the optimum sowing date (SD2). The small seeded genotype (Basabeer) and the medium one (Giza3) were not affected by the early sowing date, SD1. However, the large seeded genotypes were not consistent in their response to sowing date. Davis *et al.* (1991) suggested that, in breeding programs, heat-acclimatization potential may be the more important as a selection criterion for improving crop performance in high-temperature environments. They reported that seed weight was controlled by a large number of genes, with both additive and dominance effects.

Seed yield of all genotypes was significantly reduced (Table 4) at SD1 and SD3 by 18.2-82.1% and 44.8-68.1% for the two seasons, respectively. This finding was similar to that reported by Berry and Bjorkman (1980), who stated that early sowing dates from 2 to 23 September resulted in very low seed yield (360 kg/ha) of common bean because fewer plants survived. However, Konsens *et al.* (1991) concluded that heat stress, especially during reproductive development, causes severe yield reductions in common bean. Meanwhile, Subbarao *et al*. (1995) have reported that exposure to less extreme temperatures during critical reproductive stages can directly affect seed yield.

Estimates of relative yields YSD1/YSD2, YSD3/YSD2, stress susceptibility index (SSI) and geometric mean productivity (GMP) at early (SD1) and late (SD3) sowing dates were given in Table (5). Higher values of YSD1/YSD2 were obtained by the small seeded genotypes; Basabeer (82%), DB190-74-1(55%), UBR (92)25-2 (59%) and the medium seed size, Giza3 (64%). The lower values were obtained by the three large seeded genotypes and the medium ones Bellenber-1 and COWU-3-94-9 (20, 18, 32, 37 and 25 %, respectively). At the late sowing date (SD3), the higher values were obtained by the large seeded genotypes: Ibarya (53%), S/Hashim/98 (52%) and the medium ones; COWU-3-94-9 (56%) and Bellenber-1(55%). The three small seeded genotypes: Basabeer, DB190-74-1 and UBR (92)25-2 gave heat tolerance values ranging from 32 to 43%. The stress susceptibility index under the early sowing date (SD1) for most genotypes was above average drought susceptibility index. The lowest values; 0.33, 0.65 and 0.74 were obtained by the small seeded genotypes; Basabeer, Giza3 and UBR (92)25-2, respectively. At the late sowing date (SD3), the small seeded genotypes showed high values of susceptibility index, however, the rest genotypes gave values ranging from 0.86 to 0.98.

The highest values of geometric mean productivity at the early sowing were obtained by Basabeer (1842 kg/ha) and Giza3 (1734 kg/ha.), however, the lowest values were attained by genotypes; Ibarya (617 kg/ha), COWU-3-94-9 (726 kg/ha) and Turki-2 (856 kg/ha). At the late sowing (SD3), the highest values were recorded for Giza3 (1530 kg/ha.), Basabeer (1338 kg/ha) and Turki-1(1412 kg/ha). The two small seeded genotypes; UBR (92)25-2 and DB190-74-1 gave the lowest geometric mean productivity.

References

Amede, T.; Paul, K.; Wilson, R.; Lumbagos, L.; Hassan, K.; Irongo, D. and Nkoko, M. (2001). Strategies to improve genetic adaptation of common bean to drought prone Regions of Africa. Working Group Synthesis: 30-31 Sept, Nairobi, Kenya.

Berry, J. A. and Bjorkman, O. (1980). Photosynthetic response and adaptation to temperature in higher plants. Annul. Rev. Plant Physiology, 31: 491-543.

Davis, D. W.; Li, P.H. and Shen, Z.Y. (1991). High temperature acclimation potential of the common bean: Can it be used as a selection criterion for improving crop performance in high-temperature environments?. Field Crops Research, 27(3): 241-256.

Dickson, M. H. and Botteger, M.A. (1984). Effect of high and low temperatures on pollen germination and seed set in snap beans. J. Am. Soc. Hort. Sci., 109: 372 - 374.

Fernandez, G. C. J. (1993). Effective selection criteria for assessing plant stress tolerance. In: Adaptation of Food Crops to Temperature and Water Stress; Kuo, C.G. (ed.); AVRDC, Shanhua, Taiwan.

Fisher, R. A. and Maurer (1978). Drought resistance in spring wheat. I. Grain yield responses. J. Agric. Res. 29: 897 - 912.

Konsens, J.; Ofir, M. and Kigel, J. (1991). The effect of temperature on the production and abscission of flowers and pods in snap bean (*Phaseolus vulgaris* L.). Ann. Bot., 67: 391 - 399.

Monterroso, V. A. and Wien, H. C. (1990). Flower and pod abscission due to heat stress in bean. J. Amer. Soc. Hort.Sci., 115: 631 - 634.

Paulsen, G. M. (1974). High temperature responses of crop plants. In: Physiology and Determination of Crop Yield; Boote, K. J.; Bennett, J. M.; Sinclair, T. R. and Paulsen, G. M. (eds); Madison, WI, USA.

Subbarao, G. V.; Johansen, C.; Slnkard, A.E.; Rao, N.; Saxena, N.P. and Chauhan, Y.S. (1995). Strategies for improving drought resistance in grain legumes. Critical Reviews in Plant Science, 14(6): 469 - 523.

Weaver, M. L; Timm, H.; Silbernagel, M.J. and Burke, W. (1985). Pollen staining and high temperature tolerance of beans. J. Am. Soc. Hort. Sci.110: 797 - 799.

Table1: Interaction effects of seasons, genotypes and sowing dates on reproductive traits of common bean

Season	Genotype	Trait											
		No. of Pods /plant			No. of Seeds /Pod			100-seed wt.(g)			Seed Yield (kg/ha)		
		SD1	SD2	SD3	SD1	SD2	SD3	SD1	SD2	SD3	SD1	SD2	SD3
2003/4	Basabeer	18.0	21.0	18.0	3.0	4.0	3.0	23.3	23.0	19.0	1545	2034	887
	DB190-74-1	12.0	15.0	13.0	4.0	3.0	2.0	21.0	18.0	16.0	683	1388	717
	UBR(92)25-2	12.0	14.0	12.0	4.0	4.0	3.0	14.0	16.0	15.0	540	1165	460
	Giza 3	18.0	20.0	18.0	3.0	5.0	3.0	29.0	29.0	24.0	1081	2296	1286
	Bellenber-1	9.0	15.0	13.0	3.0	4.0	3.0	25.0	31.0	24.0	392	1854	1110
	COWU-3-94-9	11.0	12.0	13.0	3.0	3.0	3.0	28.0	32.0	26.0	300	1458	956
	Ibarya	9.0	12.0	12.0	2.0	3.0	2.0	36.0	42.0	42.0	114	1322	1052
	Turki-2	12.0	17.0	15.0	3.0	3.0	2.0	32.0	36.0	33.0	149	2047	1061
	S/Hashim/98	10.0	13.0	13.0	3.0	4.0	2.0	29.0	41.0	35.0	204	1424	944
Mean		12.0	15.0	15.0	3.0	4.0	3.0	26.1	29.6	26.1	549	1665	941

2005/6	Basabeer	20.0	27.0	19.0	2.0	4.0	3.0	22.0	21.0	18.2	1786	2039	872
	DB190-74-1	14.0	18.0	10.0	3.0	3.0	3.0	20.0	22.0	14.0	810	131	217
	UBR(92)25-2	13.0	16.0	36.0	4.0	4.0	3.0	18.0	20.0	12.0	872	1219	300
	Giza 3	23.0	24.0	18.0	4.0	4.0	4.0	27.0	27.0	22.0	1700	2028	879
	Bellenber-1	17.0	15.0	15.0	3.0	4.0	3.0	28.0	29.0	23.0	888	1578	772
	COWU-3-94-9	12.7	14.0	14.0	3.0	3.0	3.0	30.0	29.0	22.1	427	1442	654
	Ibarya	11.0	15.0	10.0	3.0	3.0	2.0	41.0	46.0	26.8	431	1446	426
	Turki-2	14.0	28.0	17.0	2.0	4.0	2.0	38.0	34.0	27.6	576	1992	913
	S/Hashim/98	16.0	19.0	14.0	3.0	3.0	2.0	39.0	32.0	28.1	726	1476	568
Mean		16.0	19.0	17.0	3.0	4.0	3.0	29.3	28.7	21.6	913	1614	622
S.E ±			0.79			0.3			0.11***			50.0***	
C.V%			14.0			23.3			8.3			17.6	

SD1= 1st October, SD2=30 October, (optimum or recommended planting date), SD3=30 November

Table 2: Main effects of nine common bean genotypes on the reproductive traits.

	Traits			
Genotypes	**No. of pods/plant**	**No. of seeds/pod**	**100-seed weight(g)**	**Seed yield Kg/ha**
Basabeer	20.0 a	3.1 a b c	20.9 e	1527 a
DB 190-74-1	13.4 b c	3.0 b c d	18.6 f	854 c d
UBR (92)25-2	17.1 a b	3.6 a b	15.8 g	760 d
Giza 3	19.9 a	3.8 a	26.3 d	1535 a
Bellenber –1	14.3 b c	3.3 a b c	26.8 c d	1099 b
COWU -3-94-9	13.1 b c	2.9 b c d	27.8 c	873 c d
Ibarya	12.1 c	2.3 d	38.8 a	799 c d
Turki–2	17.1 a b	2.9 b c d	33.2 b	1123 b
S/Hashim/98	14.7 b c	2.8 c d	34.0 b	890 c
Mean	15.7	3.1	26.9	1051
S.E ±	1.52	0.24	0.53	43.50
C.V %	41.0d	32.9	8.3	17.6

Means in the same column followed by the same letters are not significantly different at 0.05 probability level using Duncan, s Multiple Range Test (DMRT)

Table 3: Reproductive traits of the nine common bean genotypes evaluated under three sowing dates, averaged over seasons 2003/04 and 2005/06.

Treatments	No of Pods/plant	No of Seeds/pod	100-seed wt.(g)	Seed yield (kg/ha)
SD1	14.0	3.0	27.7	731
SD2	17.0	4.0	29.2	1639
SD3	16.0	3.0	23.8	781
Mean	**14.0**	**3.0**	**26.9**	**717**
S.E±	**1.1**	**0.4**	**0.2**	**70.7**
Significant Level	*****	**n.s**	*****	******

SD1= I[st] October, SD2=30 October, (optimum or recommended planting date), SD3=30 November.
*and**=indicate significant at 5% and 1% level, respectively.

Table 4: Percent reduction in seed yield in nine common bean genotypes, under three sowing dates (SD1, SD2 and SD3), averaged over 2003/4 and 2005/6 seasons.

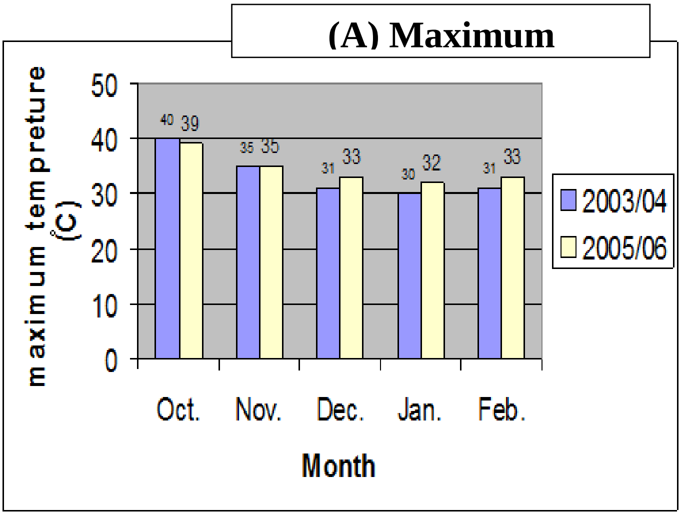
Genotype	SD2	SD1	Reduction (%)	SD3	Reduction (%)
Basabeer	2036	1666	18.2	880	56.5
DB 190-74-1	1347	747	44.5	467	65.3
UBR(92)25-2	1192	707	40.7	380	68.1
Giza-3	2162	1359	37.1	1083	49.9
Bellenber-1	1716	640	62.7	941	45.3
COWU-3-94-9	1450	364	74.9	805	44.8
Ibarya	1384	273	80.3	739	46.6
Turki-2	2020	362	82.1	987	62.6
S/Hashim/98	1450	465	67.9	755	47.9
Mean	**1665**	**731**	**56.1**	**782**	**53.1**

SD1= 1st October, SD2=30 October (optimum or recommended planting date), SD3=30 November

Table 5: Means of heat tolerance parameters in nine common bean genotypes over three sowing dates in two seasons (2003/4 and 2005/6).

Genotype	Optimum YSD2	Early YSD1	Late YSD3	YSD1/YSD2 (%)	YSD3/YSD2 (%)	SSI (SD1)	SSI (SD3)	GMP (SD1)	GMP (SD3)
Basabeer	2037	1666	880	82.0	42.0	0.33	1.1	1842	1338
DB 190-74-1	1349	747	467	55.0	35.0	0.81	1.2	1004	794
UBR(92)25-2	1192	706	380	59.0	32.0	0.74	1.3	917	673
Giza-3	2162	1391	1083	64.0	50.0	0.65	0.96	1734	1530
Bellenber-1	1716	640	941	37.0	55.0	1.1	0.87	1048	1271
COWU-3-94-9	1450	364	805	25.0	56.0	1.4	0.86	726	1080
Ibarya	1384	276	739	20.0	53.0	1.5	0.90	617	1011
Turki-2	2020	362	987	18.0	49.0	1.5	0.98	856	1412
S/Hashim/98	1450	465	756	32.0	52.0	1.2	0.92	1032	1047
Mean	1640	735	782	-	-	-	-	-	-

Optimum, Early and Late sowing days; SD1, SD2 and SD3, respectively.
YSD1, YSD2 and YSD3= seed yield at sowing date SD1, SD2 and SD3, respectively.
SSI = Stress susceptibility index.
GMP = Geometric mean of productivity.



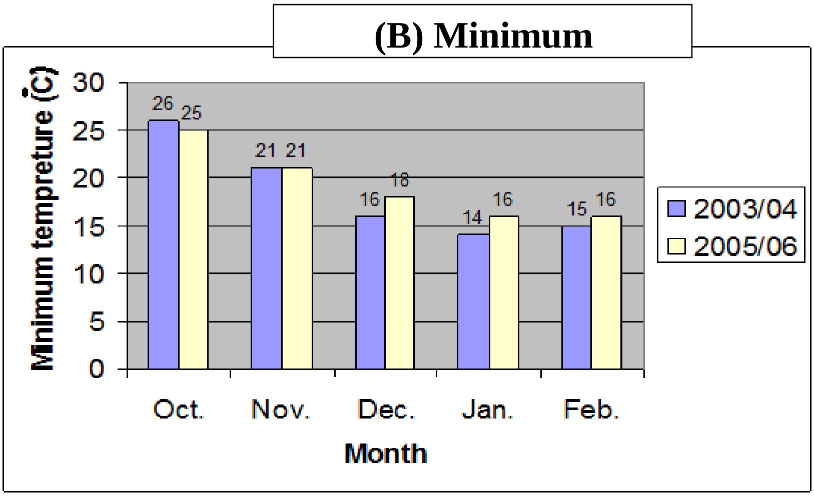


Fig. 1 (A and B): Means of maximum and minimum temperatures for two seasons (2003\04) and (2005/06).