CHAPTER 4

RESULTS

4.1 Germplasm collection

4.1.1 Parentage data

Parentage data are the information records of the component parental materials and method of synthesis of the commercial varieties. Such a record is valuable for a precise identification promising breeding materials as well as the most desired breeding approaches for planning the future course of the breeding strategy.

However, while some of the selections had pedigree records either from garden roses or old varieties of greenhouse cut roses, others had no known parentage due to the practice of making parentage of varieties a trade secret. Yet result of the crossing aim could still be confounded by inaccurate pedigree records, absence of pedigree records or misnamed and/or multiple named cultivars. Information on the trade name, code name, year of introduction and pedigree are shown in Table 4.1. 27 Varieties used for hybridization were commercial cut roses except 'Eliza' which was used as standard check for pink colour offspring. The parentages data of 10 of these varieties were obtained from the Encyclopedia of Rose Science No. 3, but the remaining 18 had no known parentage record.

Table 4.1 Pedigree data of parents

Number	Trade Name	Year	Parentage
1	Azure Sea	1983	[(Angel Face X First Prize) X Lady X]
2	Black Magic	1997	absence of pedigree records
3	Bridal Pink	1967	[Summertime seedling X Spartan seedling]
4	Dallas	1987	absence of pedigree records
5	Diplomat	1962	(Poinsettia X Tawny Gold) X Detroiter]
6	Emblem	1981	[Seedling X Sunshine]
7	Emerald	1998	absence of pedigree records
8	First Red	1990	absence of pedigree records
9	Fragrant Cloud	1967	Seedling X Prima Ballerina
10	Frisco	1987	(New Day X Minigold) X Banzai) X Antique Silk]
11	Jade	2000	absence of pedigree records
12	Josephine Charlotte	1994	absence of pedigree records
13	Kardinal	1986	Unnamed seedling X Flamingo
14	Naomi	1998	absence of pedigree records
15	Osiana	1988	absence of pedigree records
16	Paris	1974	[(DELtorche X (Sultane X Mme Joseph Perraud) X (Queen Elizabeth X Provence)]
17	Pink Noblesse	1989	absence of pedigree records
18	Raphaella	1992	absence of pedigree records
19	Ravel	1994	absence of pedigree records
20	Saphir	1989	absence of pedigree records
21	Sundance	1992	[Unnamed seedling X Emblem]
22	Texas	1993	absence of pedigree records
23	Tineke	1989	absence of pedigree records
24	Top Secret	1996	(Unnamed seedling X Unnamed seedling)
25	Vendela	1997	absence of pedigree records
26	Vivaldi	1988	absence of pedigree records
27	White Noblesse	1989	absence of pedigree records
28	Eliza/Persia	1999	absence of pedigree records

4.1.2 Genetic relationship of parents

Genetic relationships in rose parent cultivars as measured by randomly amplified polymorphic DNA (RAPD) markers were conducted through HAT-RAPD technique. Molecular marker technology became available being evaluated for their usefulness in cut-rose cultivar identification and assessing genetic diversity.

By using 28 primers to analyze 28 varieties of cut-rose, it was found that the number of bands appearance had a great diversity and a big difference in size range of bands. The 28 primers used in the present analysis are listed (Table 4.2). All primers have been tested as single primers for their ability to amplify rose. Highly polymorphic profiles were obtained with 8 of primers such as OPB-8, OPB-9, OPB-10, OPF-11, OPJ-4, OPN-03, OPAD-01 and OPAU-08, while only ‘OPR-20’1 primer was not detected. An example of a RAPD pattern is shown in Figure 4.1a and 4.1b.

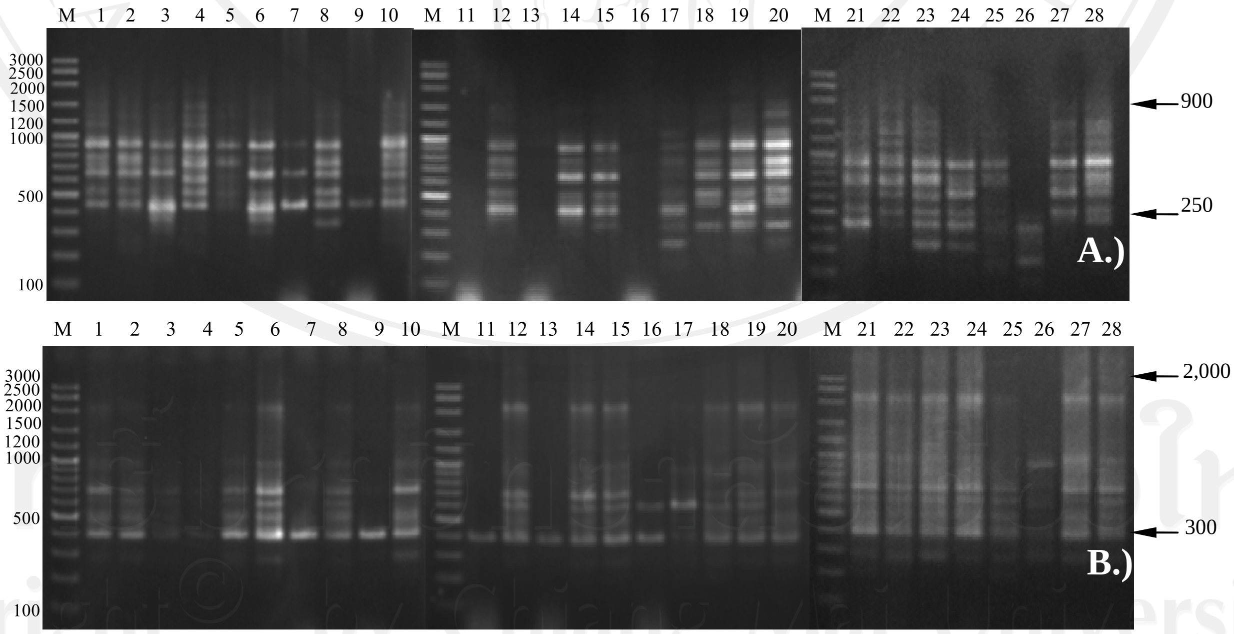


Figure 4.1 HAT-RAPD profile of 28 varieties using different primer showed different number of bands appearance between parents (A.) OPA 04 primer amplified 104 band, range 250-900 bp (B.) OPA 09 primer amplified 152 band, range 300-2,000 bp. M represents 100 bp DNA ladder. The rose parents were 1=SP, 2=DL,3=DPM, 4=TNK,5=AZ, 6=RV,7=BM,8=FC,9=FR, 10=PS, 11=EMB, 12=OSN, 13=PNB, 14=VVD, 15=NOM, 16=JSP, 17=TX, 18=RPL, 19=KDN, 20=WNB, 21=BDP, 22=TS, 23=JADE, 24=SD, 25=VDL, 26=FSC, 27=PR, 28=EMR

The relationships between the 28 cultivars based on their genetic distances were clustered in a dendrogram. DNA fingerprint data which were complied to find the genetic relation between rose varieties which had similar or different genetic according to the level of similarities by using bootstrap values. The RAPD products were scored as present (1) or absent (0) for each primer-genotype combination. The computer package PAUP 4.0 B10 program was used for cluster analysis. Most information primers were compared with that obtained with all the primers. The number of bands primer ranged from 27 to 145, and size of the amplified products varied from 0.15 kb to 2.5 kb. Similarity indices estimated on the basis of all the 28 primers ranged from 1 to 81 %.

Table 4.2 28 primers used for PCR amplification of 28 HT-roses in breeding program

Name of Primer	Sequence (5-3)	Number of bands appearance	Size range of bands [bp]
OPA-04	5`-AATCGGGCTG-3`	61	250-900
OPA-09	5`-GGTTACTGCC-3`	84	300-2000
OPA-11	5`-CAATCGCCGT-3`	86	450-1800
OPB-6	5`-TGCTCTGCCC-3`	83	300-1500
OPB-7	5`-GGTGACGCCC-3`	97	200-1500
OPB-8	5`-GGTGACGCAG-3`	121	180-2400
OPB-9	5`-TGGGGGACTC-3`	122	200-1500
OPB-10	5`-GTGACATGCC-3`	130	250-1000
OPE-4	5`-ACGGATGCC-3`	90	400-1500
OPF-11	5`-ACGGATCCTG-3`	112	250-1500
OPH-15	5`-AATGGCGCAG-3`	50	500-1500
OPH-17	5`-CACTCTCCTC-3`	69	400-1200

OPJ-4	5`-CCGAACACGG-3`	145	150-1800
OPN-02	5`-ACCAGGGGCA-3`	86	350-2500
OPN-03	5`-GGTACTCCCC-3`	103	200-1700
OPN-09	5`-TGCCGGCTTG-3`	54	220-1500
OPN-12	5`-CACAGACACC-3`	38	300-1000
OPO-14	5`-AGCATGGCTC-3`	77	200-1300
OPP-11	5`-AACGCGTCGG-3`	98	300-1200
OPR-15	5`-GGACAACGAG-3`	90	200-1300
OPT-19	5`-GTCCGTATGG-3`	27	900-1300
OPW-09	5`-GTGACCGAGT-3`	51	400-1800
OPX-13	5`-ACGGGAGCAA-3`	79	350-1200
OPAD-01	5`-CAAAGGGCGC-3`	111	200-1100
OPH-01	5`-TCCGCAACCA-3`	60	300-1000
OPH-03	5`-GGGTAACGCC-3`	90	300-1500
OPAU-08	5`-CACCGATCCA-3`	111	200-1600
OPR-20	5`-ACGGCAAGGA-3`	-	-

All primer dendrogram, cluster analysis based on similarity values classified roses genotype into 4 major groups. Each of these major groups further sub-clustered. In group one, seven of IA collections clustered separately from three of IB clusters. In the second group, six varieties individually sub-clustered. In the third group, six varieties of IIIA collections clustered separately from five varieties of IIIB collections clusters. ‘Eliza/Persia’ sub-cluster individually clustered into group IV with no relationship between whole collections.

Optimum primer dendrogram could be classified into 3 groups: Groups 1 with 16 cultivars, in Group 2 with 11 cultivars, Group 3 with a cultivar as outgroup.

Dendrogram was classified into: Group 1 and 2, which had close genetic relationship with high genetic value bootstap support 100 and 74%, which was consistent with Table 4.1, e.g. Emblem and Sundance.

Compared to the second dendrograms, it was concluded that the dendrogram from optimum primers dendrogram from 8 primers which having highly polymorphic profiles more than 100 visible bands was the best and it results were consistent with parentage data. It could be used as a breeder's tool for identifying the genetic relationship. Varietal genetic relationships between 11 rose breeders displayed a high level of genetic semilarity which benefited the breeding program (Figure 4.2).

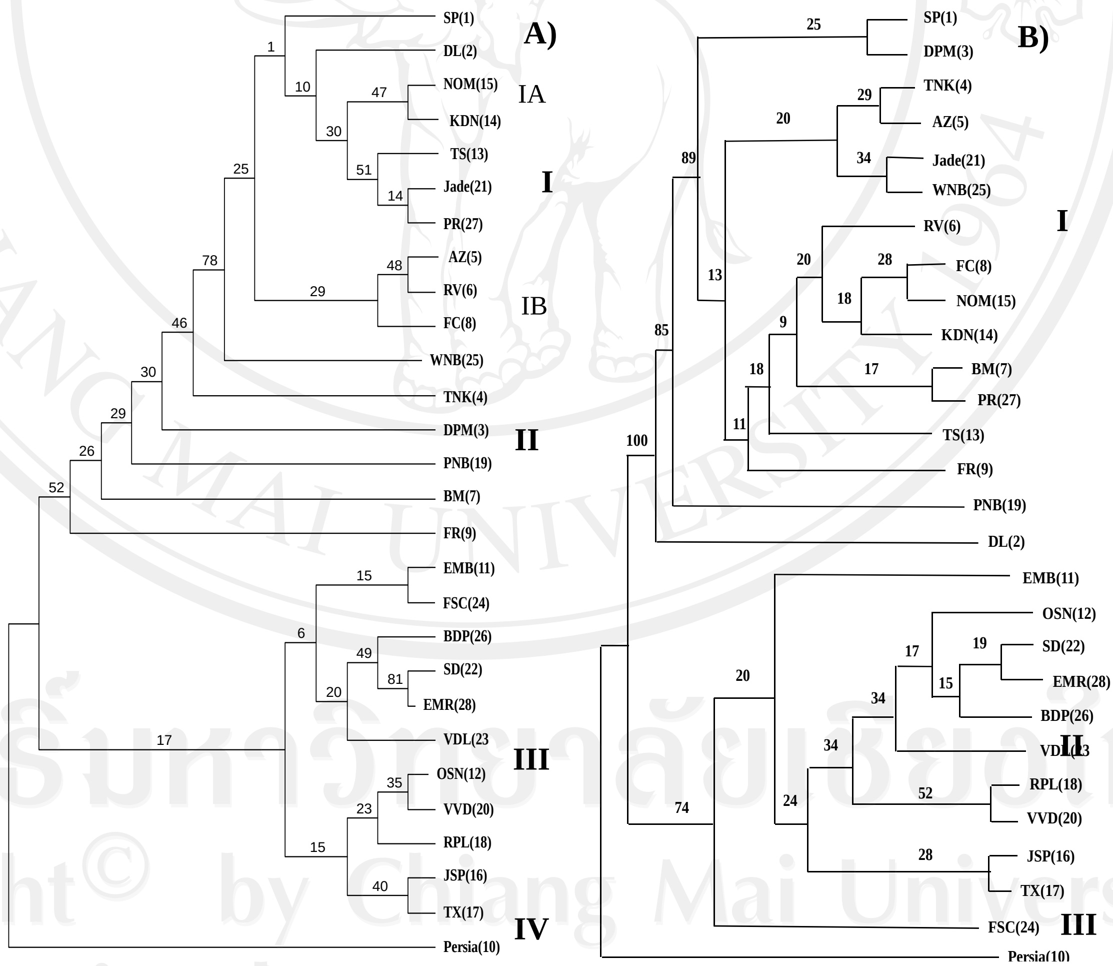


Figure 4.2 Dendrogram of 28 HT-roses cultivars generated by the neighbor-joining method from the HAT-RAPD A) All primer dendrogram B) Optimum primer dendrogram

4.2 Pairing of parents

4.2.1 Pre-hybridization stage

The abundance of pollen and good pollen germination were necessary for plants to be used as male parents. Therefore, pollen germination was firstly investigated. Artificial medium consisting of 8 g/l agar supplemented with 15% sucrose plus 100 ppm of boric acid proofed to be a successful medium. It was found out that high pollen density using scattering method promoted higher pollen germination than at low density. Pollen germination percentage was considered after 12 hrs (Figure 4.3).

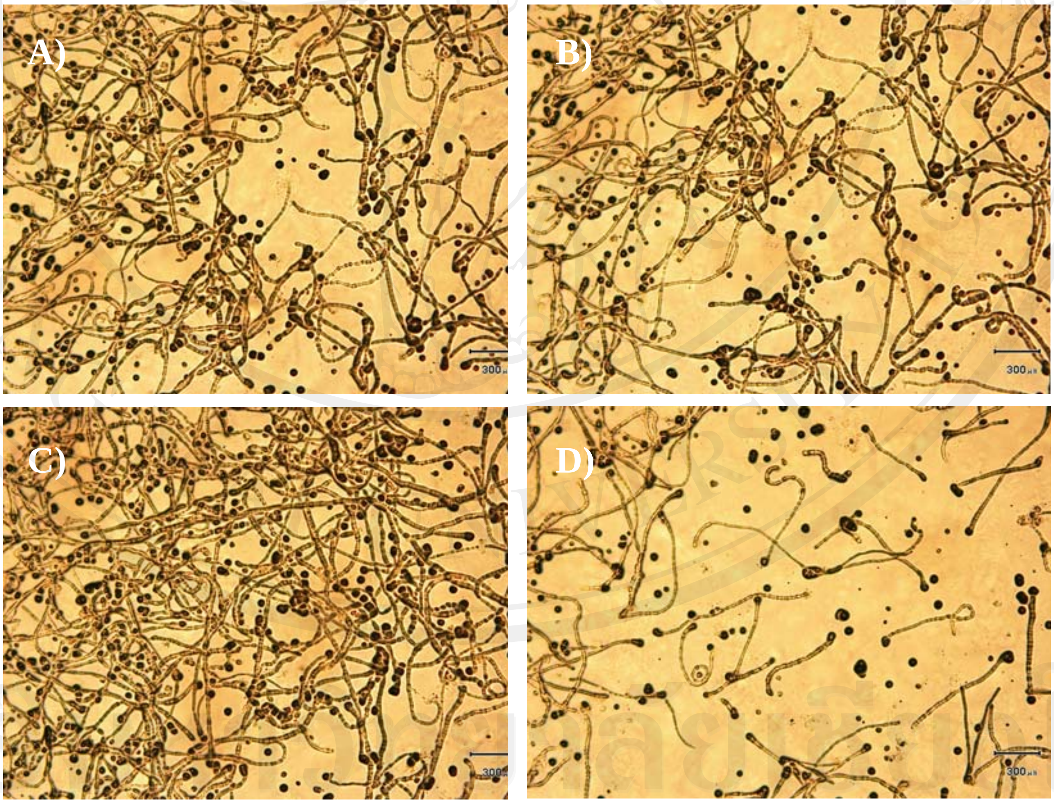


Figure 4.3 Pollen germination

A) Azure Sea, B) Dallas, C) Diplomat, D) First Red

Vegetative nucleus and generative nucleus could be observed in the germinated pollen. Division of generative cell in pollen tube and callose plug formation were observed. When the pollen tube elongated, a plug which consisted of callose, a polysaccharide and some plant growth regulators was formed inside it (Figure 4.4).

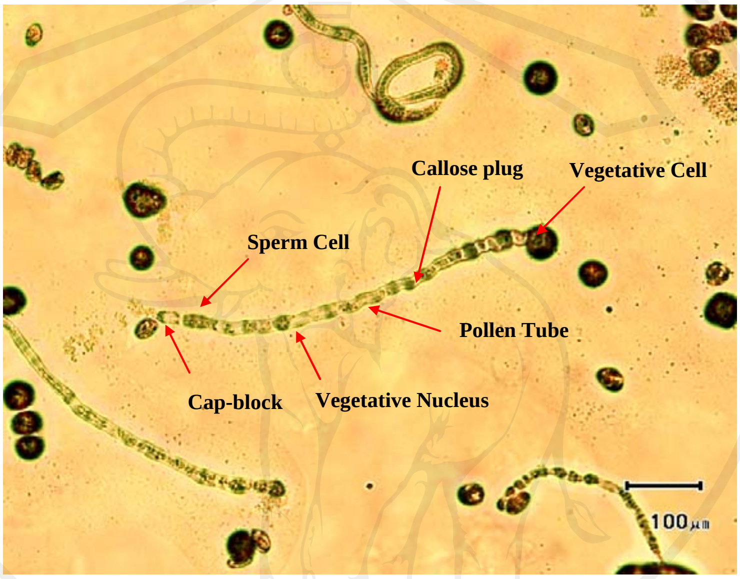


Figure 4.4 Germinated pollen

Information on male fertility was necessary in order to know the potential of each parent. Furthermore, a good number of pollen could mobilize the chemical substance into ovary to promote fruiting of rose seed and inhibition of fruit drop phenomena.

Plants with a good number of pollen and good pollen germination were further used as male parents. It was found that pollen germination percentage ranged from 3.3 to 62.1% and fourteen varieties fulfilled the requirement (Table 4.3).

Table 4.3 Screening of the 27 HT-rose for the selection of male parents

Variety	Number of plants	Pollen Releasing Score	%Pollen Germination	Suitable for using as male parent
AZ	22	4.4b	45.5c	Y
BDP	14	1.7fg	9.6p-r	N
BM	37	2.8e	23.5g-i	Y
DL	132	3.7d	38.3d	Y
DPM	122	4.9a	50.0b	Y
EMB	103	4.0cd	20.3i-k	Y
EMR	8	1.2h-j	11.3o-q	N
FC	26	3.8d	29.6ef	Y
FR	178	2.7e	24.6gh	Y
FSC	16	1.6fg	12.0o-q	N
JADE	11	0.9j	6.3rs	N
JSP	29	1.2h-j	8.9q-r	N
KDN	18	2.9e	30.9e	Y
NOM	12	0.9j	13.0n-p	N
OSN	142	3.7d	19.2j-l	Y
PNB	115	1.8f	26.7f-h	Y
PR	23	1.0ij	12.4o-q	N
RPL	17	0.5k	3.3s	N
RV	14	1.3g-i	17.2k-m	N
SD	24	1.4gh	13.1n-p	N
SP	116	1.8f	27.2e-g	Y
TNK	137	1.8f	15.1m-o	Y
TS	30	1.0ij	10.8 p-q	N
TX	17	3.7d	22.9h-j	Y
VDL	30	0.9j	16.4l-n	N
VVD	65	4.2bc	62.1a	Y
WNB	22	1.1h-j	24.1g-i	N
MEAN	54.8	2.3	22.0	
SD	52.6	1.3	14.0	
VARIANCE	2767.4	1.8	194.8	
SE MEAN	10.1	0.1	1.2	
CV	96.0	11.37	12.78	
F-test		**	**	
MINIMUM	8	0.5	3.3	
MAXIMUM	178	4.9	62.1	

Data from HAT-RAPD and Table 4.3 were used to create the 2 dendrogrames i.e. pollen releasing and pollen germination. The two dendrogrames showed that 3 groups similar to the information obtained from 8 optimum primers HAT-RAPD, changed the cultivar within the groups, but did not match the experiment data i.e.Azure Sea having 45.5 germination percentage remained in the same group as Tineke.The result showed that the 2 dendrograms were unable to identify the 28 cultivars.

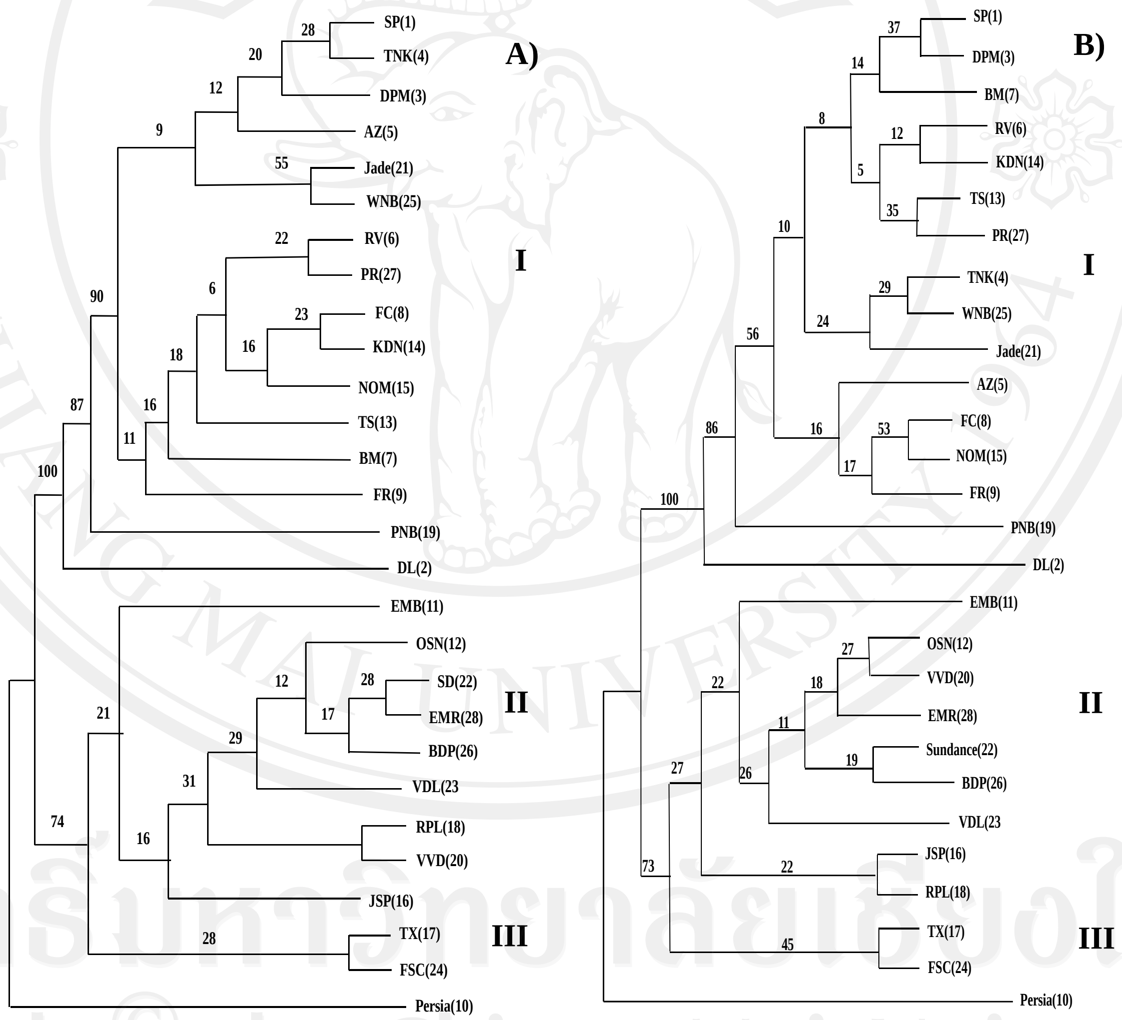


Figure 4.5 Dendrograms of 8 opimized primer combined with data from Table 4.3

A) pollen releasing B) pollen germination

4.2.2 Hybridization stage

Hybridization was made in a period of time determined by the flowering time of each variety between 14 fixed male parents and 27 female parents (Appendix I1-11).

7,844 flowers were pollinated from 268 crossing combinations. 196 successful crossings were obtained from 27 variety parents (Table 4.4).

Table 4.4 Cross-compatibility between 27 varieties combinations

F/M	Code	1	3	4	5	6	8	9	13	15	16	21	22	24	26
AZ	1	83.3		64.9	86.2	80.0		41.2	FD	52.4	50.0		58.3		50.0
BDP	2		FD	13.3	33.3	20.0		50.0	40.0	58.3		FD	FD		FD
BM	3		FD	25.8	20.5	7.7		25.0	FD	85.2	FD		66.7		10.5
DL	4			FD	FD	FD		FD	FD	FD	FD		FD		FD
DPM	5	42.9	40.0	43.0	67.3	90.2		53.7	FD	71.4	18.8	30.4	45.0	33.3	50.0
EMB	6	9.5	18.2	23.3	84.4	29.2	75.0	47.4	FD	71.3	20.0	80.0	FD		76.7
EMR	7			3.6	25.0	FD		FD	FD						
FC	8			29.5	73.3	10.7	FD	36.4	FD	86.2	33.3		40.0		53.8
FR	9		5.6	59.5	92.1	28.5	FD	75.0	FD	77.2	15.4	84.6	15.0	FD	80.0
FSC	10	FD		8.6	D	50.0		FD	66.7	18.8	FD				70.0
JADE	11			25.0	71.4			33.3	FD	33.3	FD		33.3		
JSP	12	FD		22.5	81.8	55.6		14.3		35.3	FD	33.3	FD		4.3
KDN	13		50.0	55.3	77.3	33.3		16.7		26.9			28.6		33.3
NOM	14		33.3	11.1	80.0			FD	FD	50.0					FD
OSN	15	FD	FD	37.1	82.0	69.4	40.0	19.0		21.7	71.4	48.1	84.2	71.4	57.8
PNB	16	60.0	60.0	64.0	97.9	81.7		50.0	50.0	72.9	FD	28.6	66.7	10.0	62.2
PR	17			19.4	57.1	62.5		47.6	FD	64.7		FD			FD
RPL	18	2.8			FD	8.3		FD	FD	16.7	FD	FD	FD		FD
RV	19			7.7	41.7	33.3		66.7		50.0			33.3		FD
SD	20			28.6	38.5	11.8	12.5	54.5		75.0	66.7		66.7		66.7
SP	21			47.4	94.7	16.5	FD	56.0	FD	85.0	7.1		80.0		95.1
TNK	22	FD	28.6	29.0	60.8	52.5	20.7	34.9	25.0	45.0	FD	37.5	54.5		56.5
TS	23			11.6	25.0	FD		20.0	FD	75.0	FD		FD		50.0
TX	24	62.5		4.1	23.1	28.6	20.0	46.2	FD	75.0	16.7		FD	FD	66.7
VDL	25			9.2	57.9	13.0		47.6		76.9	FD	FD	33.3		7.7
VVD	26	FD	28.6	23.1	84.6	57.1		71.0	FD	58.8	42.9	40.0	50.0		40.0
WNB	27		FD	14.3	44.4	33.3		15.8		35.7	FD	FD			55.6

Note: FD=fruit drop

From Table 4.4, the data of the percentage of fruit seting and fruit drop were analyzed in combine with the data of optimum primers from HAT-RAPD to create the phyloginic tree. Both phyloginic tree presented could be catagoried into 3 groups as well. The results showed that grouping by fruit setiting percentage and fruit drop classified incorrectly. i.e. classified Vivaldi and Raphaella in same group both fruit setting and fruit drop, while Table 4.4 present Vivaldi had highly fruit setting percentage (Figure 4.6).

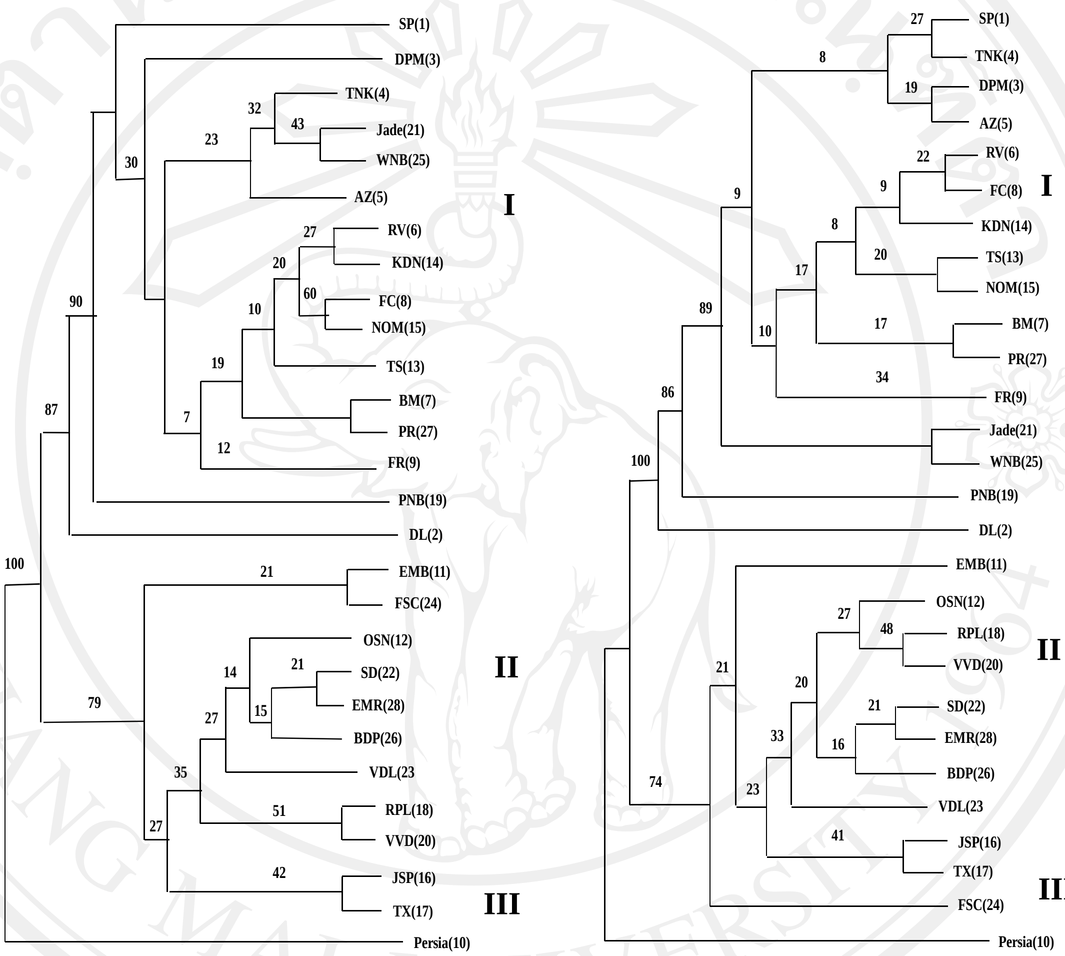


Figure 4.6 Dendrograms of 8 opimized primer combined with data of fruit set (left) and fruit drop (rigth)

After for 4 months, 3,299 hips were harvested where 47,266 seeds were collected. Seed set could be classified using pollination index (PI) into 3 categories as few seeds, some seeds and many seeds. Most combinations gave few seeds. The result indicated that seed set depended on cross-compatibility and parent combination (Table 4.5).

Table 4.5 Pollination index

F/M	Code	1	3	4	5	6	8	9	13	15	16	21	22	24	26
AZ	1	F		M	S	M		S	X	M	F		M		M
BDP	2		X	F	F	F		F	F	S		X	X		X
BM	3		X	F	F	F		F	X	S	X		F		F
DL	4			X	X	X		X	X	X	X		X		X
DPM	5	S	S	S	M	M		S	X	M	F	F	S	F	S
EMB	6	F	F	F	F	F	S	F	X	F	F	F	X		F
EMR	7			F	F	X		X	X						
FC	8			F	F	F	X	X	X	S	F		F		F
FR	9		F	F	F	F	X	X	X	F	F	F	F	X	F
FSC	10	X		F	X	F		X	S	F	X				F
JADE	11			S	F			F	X	S	X		F		
JSP	12	X		F	F	F		F		F	X	F	X		F
KDN	13		F	S	S	F		F		S			F		M
NOM	14		F	F	S			X	X	S					X
OSN	15	X	X	S	M	S	S	S		S	S	S	S	S	S
PNB	16	M	M	S	M	S		S	S	M	X	S	S	F	S
PR	17			F	F	F		F	X	M		X			X
RPL	18			F	X	F		X	X	F	X	X	X		X
RV	19			F	S	F		S		F			F		X
SD	20			S	S	F	F	S		S	S		S		S
SP	21			M	M	F	X	S	X	M	F		S		S
TNK	22	X	F	S	S	S	F	S	F	M	X	S	S		S
TS	23			F	F	X		F	X	F	X		X		M
TX	24	S		F	S	S	F	F	X	S	F		X	X	F
VDL	25			F	F	F		F		M	X	X	S		F
VVD	26	X	S	F	M	S		S	X	M	F	F	S		F
WNB	27		X	F	F	F		F		F	X	X			S

Note: Seed set: FS=Few seeds (PI=<5), SS=some seeds (PI=6-12), MS=Many seeds (PI=>12), X=fruit drop

The results from the breeding pairs elucidated that some varieties were suitable to be male plants while others to be female plants.

4.2.3 Post-hybridization stage

39,707 seeds from 193 crosses were stratified at 4°C for 2 months and then sown in seedling basket. Seeds from 75 pairings failed to germinate. 7,132 seedlings were obtained from 118 crosses. Germination percentage was 18% and 15.6% were healthy seedlings. The pollination efficiency was also calculated, where the number of seedlings of each combination could be classified into 3 groups, few, some and many seedlings (Table 4.6). The seedlings from this stage were further evaluated (Table 4.7).

Table 4.6 Pollination efficiency

F/M	Code	1	3	4	5	6	8	9	13	15	16	21	22	24	26
AZ	1	F		S	S	F		F	X	F	X		S		M
BDP	2		X	F	NG	NG		NG	F	NG		X	X		X
BM	3		X	F	F	F		NG	X	NG	X		NG		NG
DL	4			X	X	X		X	X	X	X		X		X
DPM	5	F	F	M	M	S		F	X	F	NG	F	F	NG	F
EMB	6	F	NG	F	F	F	S	F	X	NG	NG	NG	X		F
EMR	7			NG	NG	X		X	X						
FC	8			F	F	NG	X	F	X	F	F		F		F
FR	9		NG	F	F	NG	X	F	X	NG	F	NG	NG	X	F
FSC	10	X		F	X	NG		X	NG	NG	X				F
JADE	11			F	NG			NG	X	NG	X		NG		
JSP	12	X		F	NG	NG		F		NG	X	F	X		F
KDN	13		NG	F	NG	NG		NG		NG			F		F
NOM	14		F	F	NG			X	X	NG					X
OSN	15	X	X	F	F	NG	F	F		F	NG	F	F	F	F
PNB	16	F	NG	S	F	F		F	F	F	X	NG	F	NG	F
PR	17			F	NG	NG		NG	X	NG		X			X
RPL	18			NG	X	NG		X	X	NG	X	X	X		X
RV	19			F	F	NG		NG		NG			NG		X
SD	20			F	F	NG	F	F		NG	NG		F		F
SP	21			S	S	F	X	S	X	F	NG		F		F
TNK	22	X	NG	F	S	F	NG	F	F	F	X	F	F		F
TS	23			F	NG	X		NG	X	NG	X		X		NG
TX	24	F		F	F	F	NG	F	X	NG	NG		X	X	NG
VDL	25			F	NG	F		NG		NG	X	X	NG		NS
VVD	26	X	NS	F	F	F		F	X	F	NG	F	NS		F
WNB	27		X	F	F	F		F		F	X	X			F

Note: Seed germination: F=Few seedlings, S=some seedlings, M=Many seedlings, X=fruit drop, NS=not sown seeds, NG=not germinated

The results could be concluded as follows:

a.) Female parents effected on the number of pollinated flowers, %fruit set, number of seeds/crosses, germination percentage, number of germinated seedling/crosses and number of healthy seedling/crosses.

b.) Male parents effected on the number of seeds/hips and % healthy plants.

Table 4.7 Hybridization results

	Crossing combination	Amount	Percentage
Pollinated flowers	268	7,844	100.0
Harvested hips	196	3,299	42.0
Harvested seeds	196	47,266	-
Seeds sown	193	39,707	100.0
Germinated seeds	118	7,132	18.0
Healthy seedlings	118	6,202	15.6

4.3 Selection

4.3.1 Seedling stage

At this stage the seedlings were 1-2 months old in the seedling trays with two to three leaves. The flower bud was not yet visible.

Of the 7,132 seedlings obtained, 332 plants with abnormal cotyledon or necrosis were discarded. 336 plants infected with damping off and powdery mildew diseases were also discarded. Two months latter, 262 stunted seedlings were further eliminated. It was concluded that at this stage 13% of seedlings were discarded and 87% were selected with the total number of 6,202 plants which would be used for the next evaluation stage (Table 4.8).

Table 4.8 Plants discarded during seedling stage

Characteristic	Before Selection	Number Discarded	Remaining
Abnormal seedlings	7,132	332	6,800
Disease susceptible seedlings	6,800	336	6,464
Slow germinated seedlings	6,464	262	6,202
Total	7,132	930	6,202
Percentage	100.0	13.0	87.0

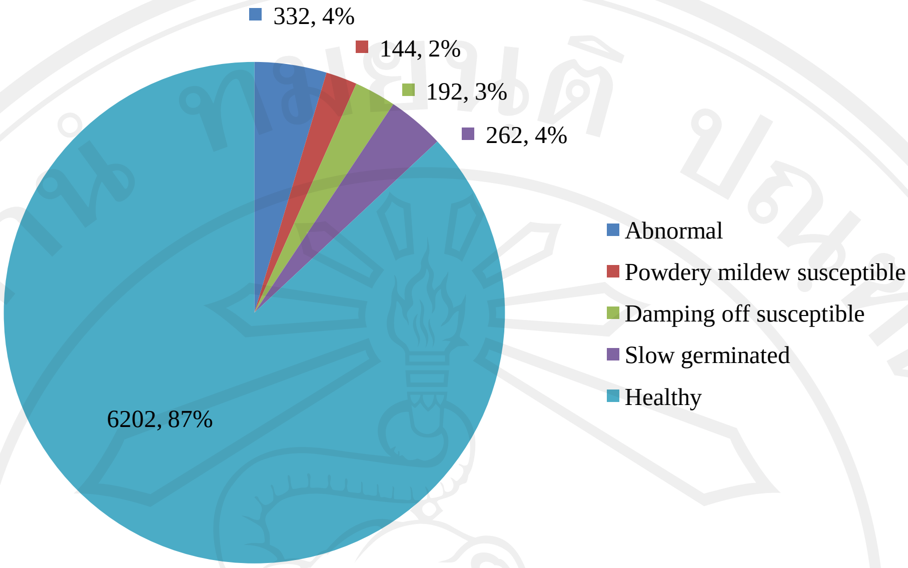


Figure 4.7 Discard percentage of seedling stage

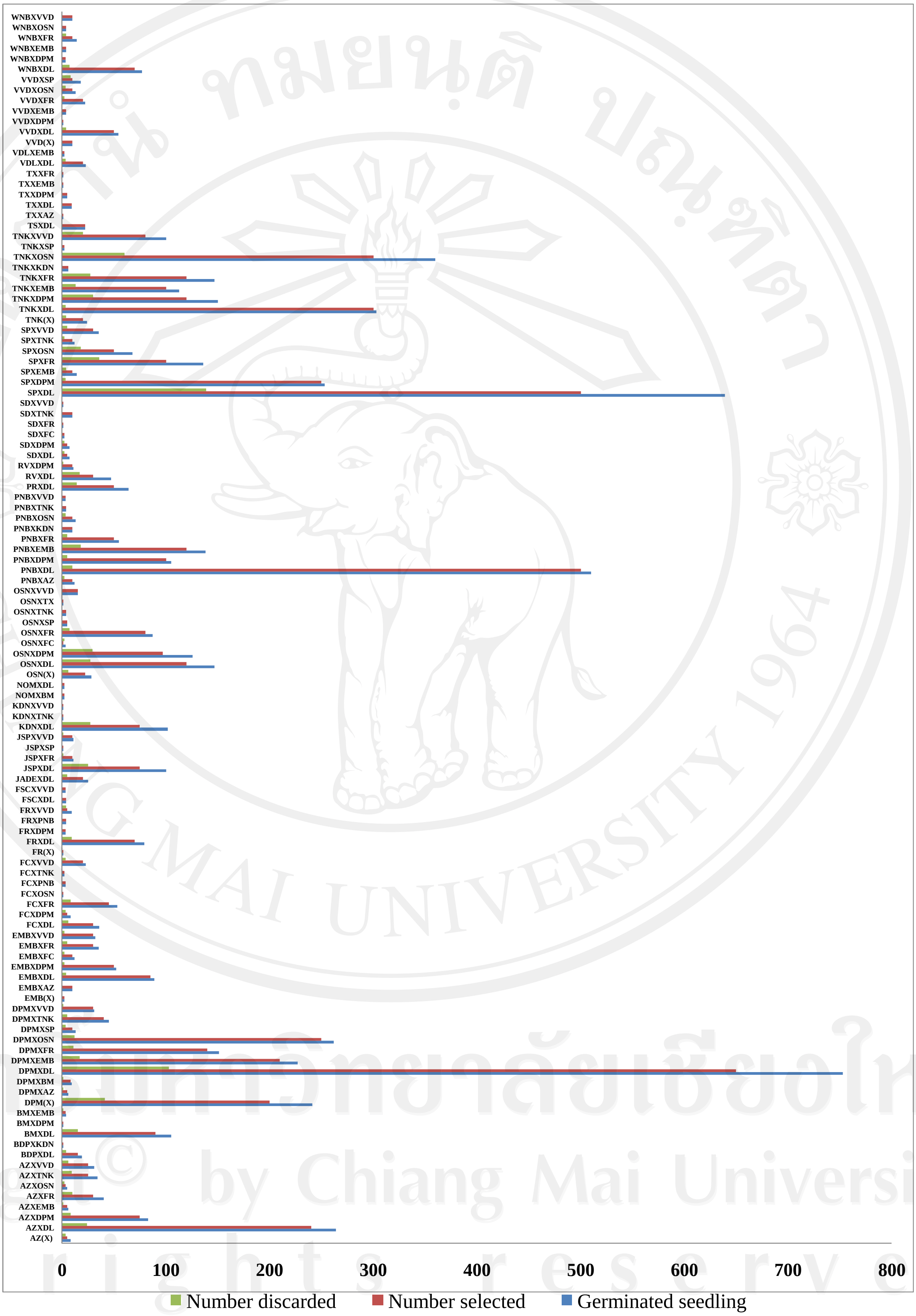


Figure 4.8 Number of germinated seedlings

4.3.2 Small plant size stage (4 inch pot)

Design of selection criteria:

The basic information

A sample of 150 rose offspring was randomed to investigate the selection criteria of the discard traits using 4 traits i.e. stem length, number of leaves, flower size, flower diameter and number of petals, based on the data from 3 different bud sizes as illustrated in Table 4.9. The table showed that the same stage had 3 significantly different traits except number of petals. It showed that 3 traits could be used as criteria in this stage.

Table 4.9 Four growth traits of 150 sample plants, using bud size criteria

Bud size (cm)	Bud size (cm)	Flower size (cm)	Stem length (cm)	Number of petals
Large (0.8-1.0)	0.9±0.1a	6±1a	19±3a	23±7
Medium (0.5-0.7)	0.7±0.0b	6±1a	19±3a	22±8
Small (0.2-0.4)	0.4±0.0c	5±1b	17±3b	21±7
Average	0.7±0.2	6±1	18±3	22±7
LSD0.05	0.02	0.4	1.2	2.9
F-test	**	**	*	ns
CV (%)	8.2	16.3	16.5	32.9

Figure 4.9, the distribution of traits from small to medium plant size was conducted by measuring each trait as presented in Table 4.2.

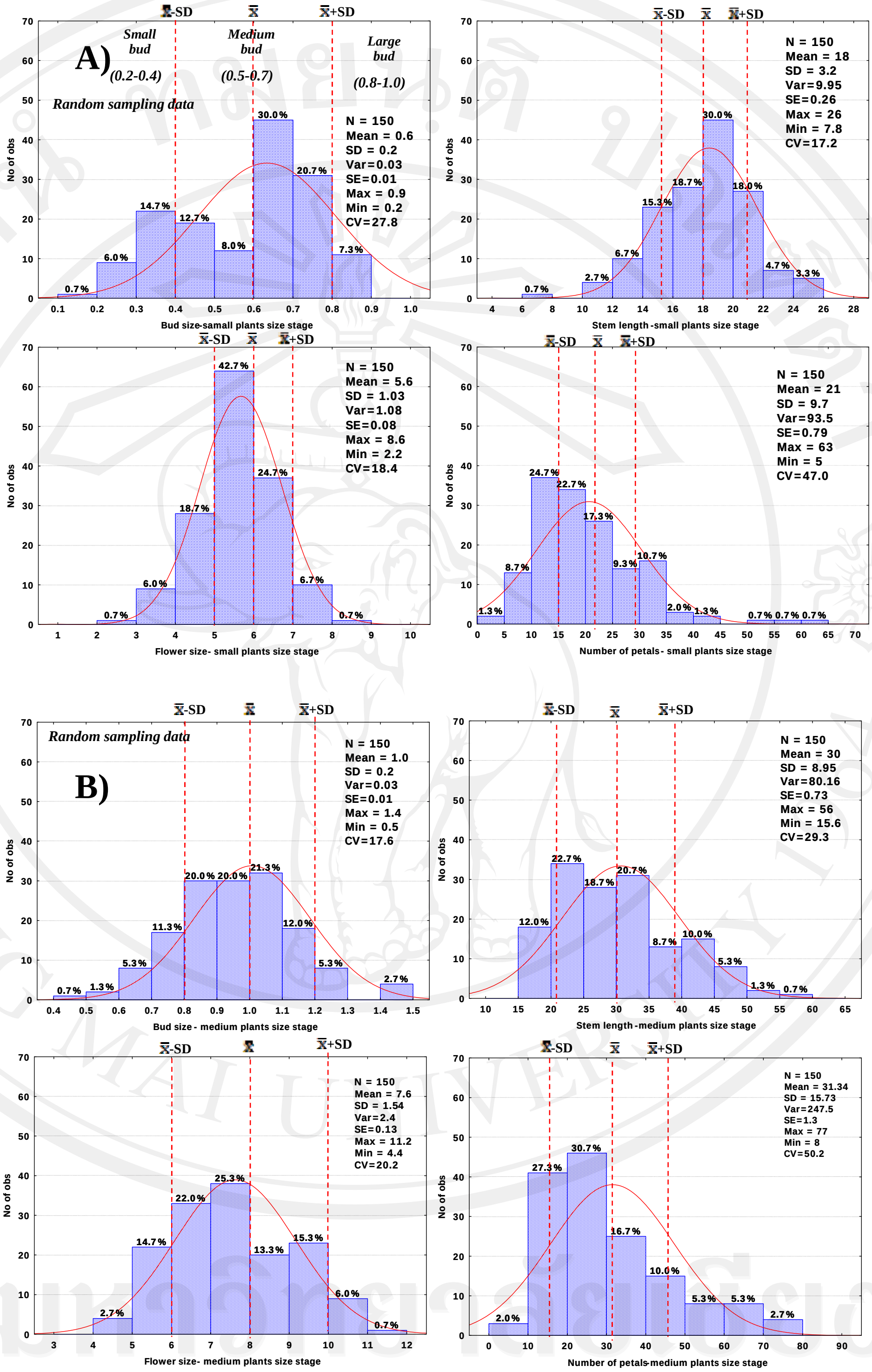


Figure 4.9 The distribution of 150 random sampling data

A) Small plant size stage

B) Medium plant size stage

The change of traits in next stage

Our initial assumption was that difference in bud sizes in relation to plant growth in the small plant stage would be tranfered to the next stage (medium plant size), but the result showed that it was not so. In medium plants stage, although bud sizes were still different, differnce in plant growth was minimal. It could be concluded that traits could change in any stage. Therfore, trait criterion for selection as shown in Table 4.10 should be used both in small plant stage and medium plant stage.

Table 4.10 Growth traits from small to medium plant size of 150 sample plants

Small plant size stage	Medium plants size stage			
Bud size (cm)	Bud size (cm)	Flower size (cm)	Stem length (cm)	Number of petals
Large (0.8-1.0)	1.1±0.2a	8±1	33±15	33±15
Medium (0.5-0.7)	1.0±0.2b	8±2	31±16	31±16
Small (0.2-0.4)	0.9±0.2c	7±2	30±17	30±17
Average	1.0±0.2	8±2	30±9.0	31±16
LSD0.05	0.06	0.60	3.55	6.24
F-test	**	ns	ns	ns
CV (%)	16.0	20.1	29.4	50.5

Correlation between traits and stage of growth

Table 4.11 showed phenotypic traits correlation. It is the result of an experiment with the selection based on bud size criteria, where offspring were selected for all traits: 1) stem length, 2) bud size 3) flower size and number of petals. SM is small plant size stage, MD is medium plant size stage.

Table 4.11 Correlation of various traits

		Stem length		Bud size		Flower size		No. of petals	
		SM	MD	SM	MD	SM	MD	SM	MD
Stem length	SM	1.0							
	MD	0.3**	1.0						
Bud size	SM	0.2**	-0.0	1.0					
	MD	0.1	0.3**	0.5**	1.0				
Flower size	SM	0.3**	0.1	0.5**	0.3**	1.0			
	MD	0.1	0.4**	0.2*	0.5**	0.5**	1.0		
No. of petals	SM	0.0	-0.1	0.1*	0.2**	0.1	0.0	1.0	
	MD	-0.1	0.0	0.1	0.2**	0.0	0.0	0.7**	1.0

Note: SM=small plant size stage, MD=medium plant size stage

The results showed that: 1) The possitive correlations of same traits between different stages were stem length, bud size, flower size and number of petals.2) The possitive correlations between traits within stage, on SM-stage were stem length-bud size, stem length-flower size, bud size-flower size, bud size-number of petals and on MD stage were, stem length-bud size, stem length-flower size, bud size-flower size and bud size-number of petals. 3) The possitive correlation between different traits and stage were bud size SM-flower size MD, bud size SM-number of petals MD. It could be concluded that the selection for the given traits affected the level of the other traits within stage and next stage. Correlations between various traits of sample plants were presented in figure 4.10 and 4.11.

Multivariate selection in whithin stage

The multivariate from 3 traits against desired trait in relation to the distribution was shown in figure 4.10. The changes in correlated traits occurred in the selection indicated that one of the traits was selected from the population, as could be seen from the graphs; the selection for the given traits affected other traits. Therefore, it was possible to reduce test plants by selecting good plants with 4 good traits, and eliminate plants with poor traits.

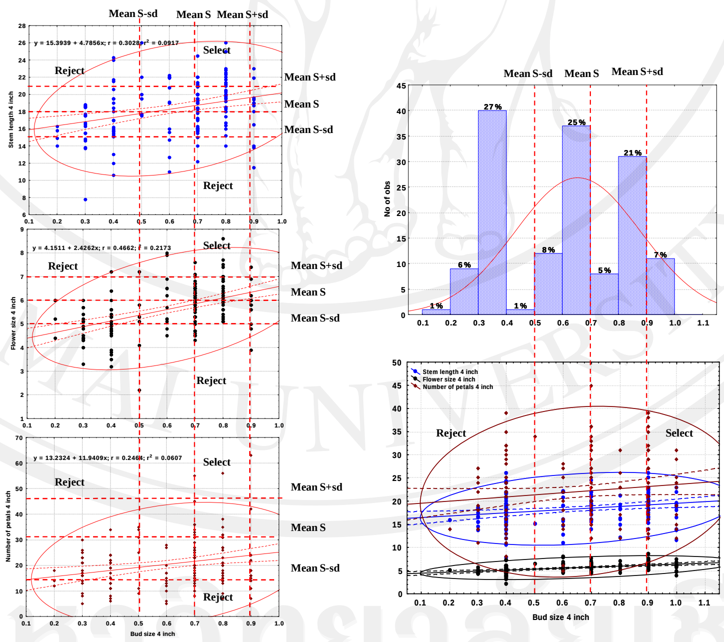


Figure 4.10 Correlation of multi-traits selection at small plant size stage

The Optimal same trait in multistage

Figure 4.11 showed the relationship in the same traits between stages of growth from the data of table 4.11. Although, Table 4.10 showed that the different bud size could not be used as criteria in medium plant size stage, but the correlation in Table 4.11 were possitive. The correlation of same traits showed high siqnificance between 2 stages, proving that it was possible to predict the traits in the next stage with high precision.

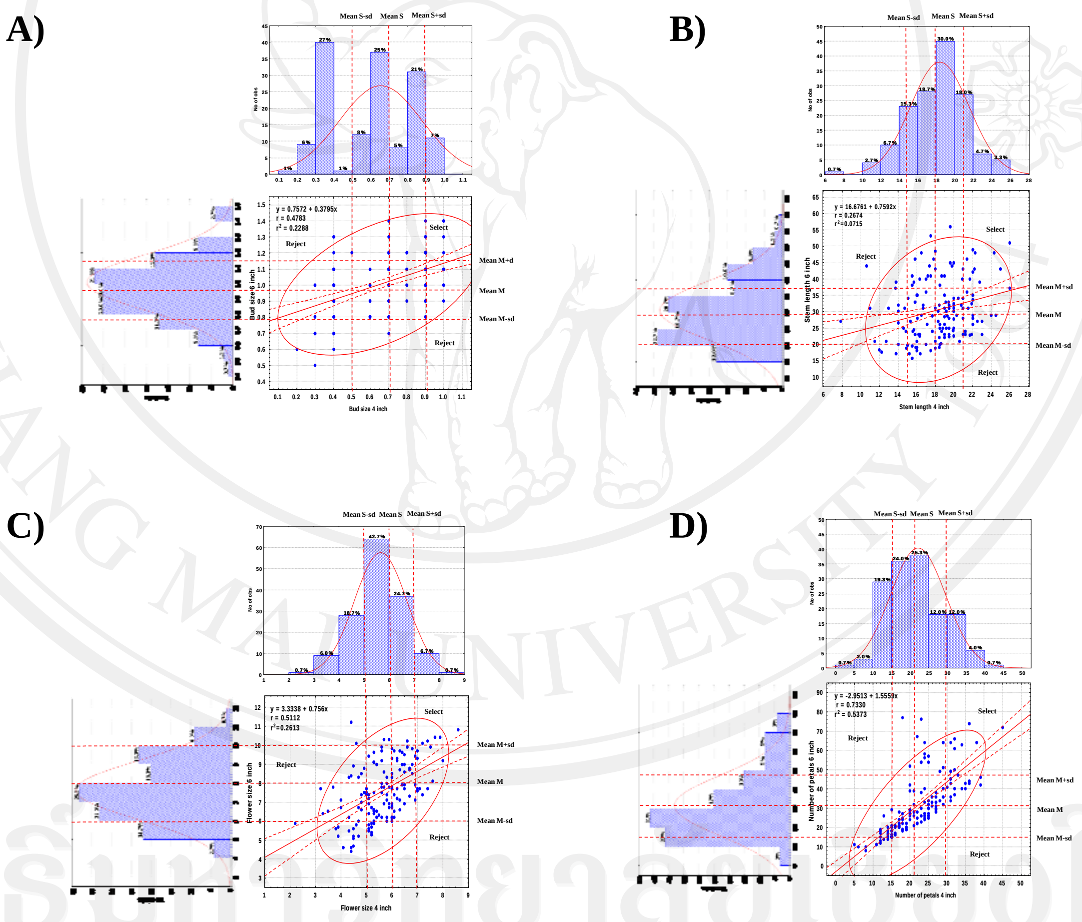


Figure 4.11 Correlation of multi-trait between small and medium plant size stage

A) Bud size B) Stem length

C) Flower size D) Number of petals

Setting up minimum levels for selection criteria:

To prove the hypothesis, the minimum levels of trait performances were established, using criteria of mean and standard deviation (mean-sd, mean and mean+sd). Any plants having good characters higher than the minimum levels would be selected by simulation model of selection from the actual data.Selection propotion for growth traits in 3 levels obtained from the data of different bud size traits were investigated and presented in table 4.12.

Table 4.12 The minimum level of growth stage of small plant and medium plant stage

Growth stage	Selection Criteria	Bud size (cm.)	Flower size (cm.)	Stem length (cm.)	No. of petals
Small plant size	SC2-1 (mean-sd)	0.5	5	15	15
	SC2-2 (mean)	0.7	6	18	22
	SC2-3(mean+sd)	0.9	7	21	29
Medium plant size	SC3-1(mean-sd)	0.8	6	21	15
	SC3-2(mean)	1.0	8	30	31
	SC3-3(mean+sd)	1.2	10	39	47

Interpretation

Selection differential of phenotypic traits computed from mean of univariate trait –mean before selection (control). The results showed that model 1 (mean-sd) was the best (Table 4.13). Although, model 1 gave good performance plants mean and selection differential in 4 traits, lower than model 2, it gave higher remaining number of plants for selection in next stage. At medium plant size stage, model 1 gave lower number of plants to discard in medium stage than model 2. This criterion therefore had higher precision than model 2.

Model 2 had higher discard percentage than model 1, but gave small number of plants after selection in medium plant size stage. It showed that this criterion was over optimum selection intensity.

Model 3 had the highest selection differentials in two traits but unusable to discard with SC1-3 criteria on number of petals, cause these criteria discarded all of plants. It showed that the common

It proved that four traits in same stage could be used as selection criteria in low minimum level to selection because plant performance would develop in next stage, if using high level of selection intensity in individual traits could be selected in few traits, may reduced the number of plants until not enough plants to select in next stage.The results showed that selection for one trait reduced selection intensity for any one trait. For the same stage, the selected plants should be had the most of good characteristics and continue to selection in the next stage by eliminate the lower trait performance plants. The intensity level of selection in any trait did affect the number of population in other trait. Rose breeder should choose the low level of selection intensity, because plants were still growing further. The optimized level of selection should be mean-sd level, because individual plants which had poor characteristics could be eliminated from the population, and had high precision in the growth of selected plants.When traits had a developmental sequence in ontogeny, independent culling from multistage selection for multiple traits was the most efficient procedure.

Table 4.13 Simulation model for finding out the optimal intensity level for selection criteria (data of 150 sampling individuals)

Model	Variable	Small plants size stage				SM stage	Medium plants size stage				MD stage	Total	Remaining
		SL	BS	FS	NP	Discarded	SL	BS	FS	NP	Discarded		
Control	Mean	18.4	0.6	5.6	20.6	0	30.6	1.0	7.6	31.3	0	0	0
	SD	3.2	0.2	1.0	9.7		9.0	0.2	1.5	9.7			
1=SC2-1	Criteria	15	0.5	5	15		21	0.8	6	21			
	Number	19	27	13	21	80	6	0	1	0	7	87	63
	p(%)	12.7	18.0	8.7	14.0	53.4	4.0	0	0.6	0	4.6	58.0	42.0
	Mean	19.5	0.7	6.1	24.3		32.5	1.1	8.1	35.0			
	SD	2.3	0.1	0.6	8.1		8.4	0.1	1.3	13.2			
	S	1.1	0.1	0.5	3.7		1.9	0.1	0.5	3.7			
2=SC2-2	Criteria	18	0.7	6	22		30	1.0	8	30			
	Number	61	27	22	21	131	7	2	5	1	15	146	4
	p (%)	40.7	18.0	14.7	4.0	87.3	4.7	1.3	3.3	0.7	10.0	91.3	2.7
	Mean	20.8	0.8	6.6	28.4		37.5	1.2	9.3	47.3			
	SD	1.8	0.1	0.5	4.1		6.9	0.2	0.6	5.3			
	S	2.4	0.2	1.0	7.8		6.9	0.2	1.7	16.0			
3=SC2-1	Criterria	21	0.9	7	29		39	1.2	10	39			
	Number	116	32	2	-	150	-	-	-	-	-	-	-
	p (%)	77.3	21.3	1.3		100	-	-	-	-	-	-	-
	Mean	22.5	0.9	5.0	15.5		-	-	-	-			
	SD	0.8	0.0	1.5	0.7		-	-	-	-			
	S	4.1	0.3	-	-		-	-	-	-			

Note: *p (%)* = selection propotion; SL=stem length, BS= bud size, FS= flower size, NP= number of petals, SM=small plant size stage, MD= medium plant size stage

Application of selection methods

The selected seedlings from seedling stage were transplanted into 4-inch pot and they started to flower. The approximate age was 6 months.

From 6,202 selected plants from seedling stage, the elimination was done using the following criteria: 497 plants with short stem, 875 plants with small bud size, 210 plants with small flower size, 370 plants with few petals. The totals of 1,952 plants (31.5 %) were eliminated (Table 4.14 and Figure 4.12). When the selection of this stage was over it was clearly seen that the plants were more uniform in terms of flowering and plant growth which indicated that the discard criteria proved successful.

Table 4.14 Plants discarded during small plant size stage

Characteristics	Discard Criteria	Before Selection	Number Discarded	Remaining
Stem length	<15 cm	6,202	497	5705
Bud size	< 0.5 cm	5705	875	4830
Flower size	<5.0 cm	4830	210	4620
Number of petals	<15 petals	4620	370	4,250
Total		6,202	1,952	4,250
Percentage		100.0	31.5	68.5

Before and after selection

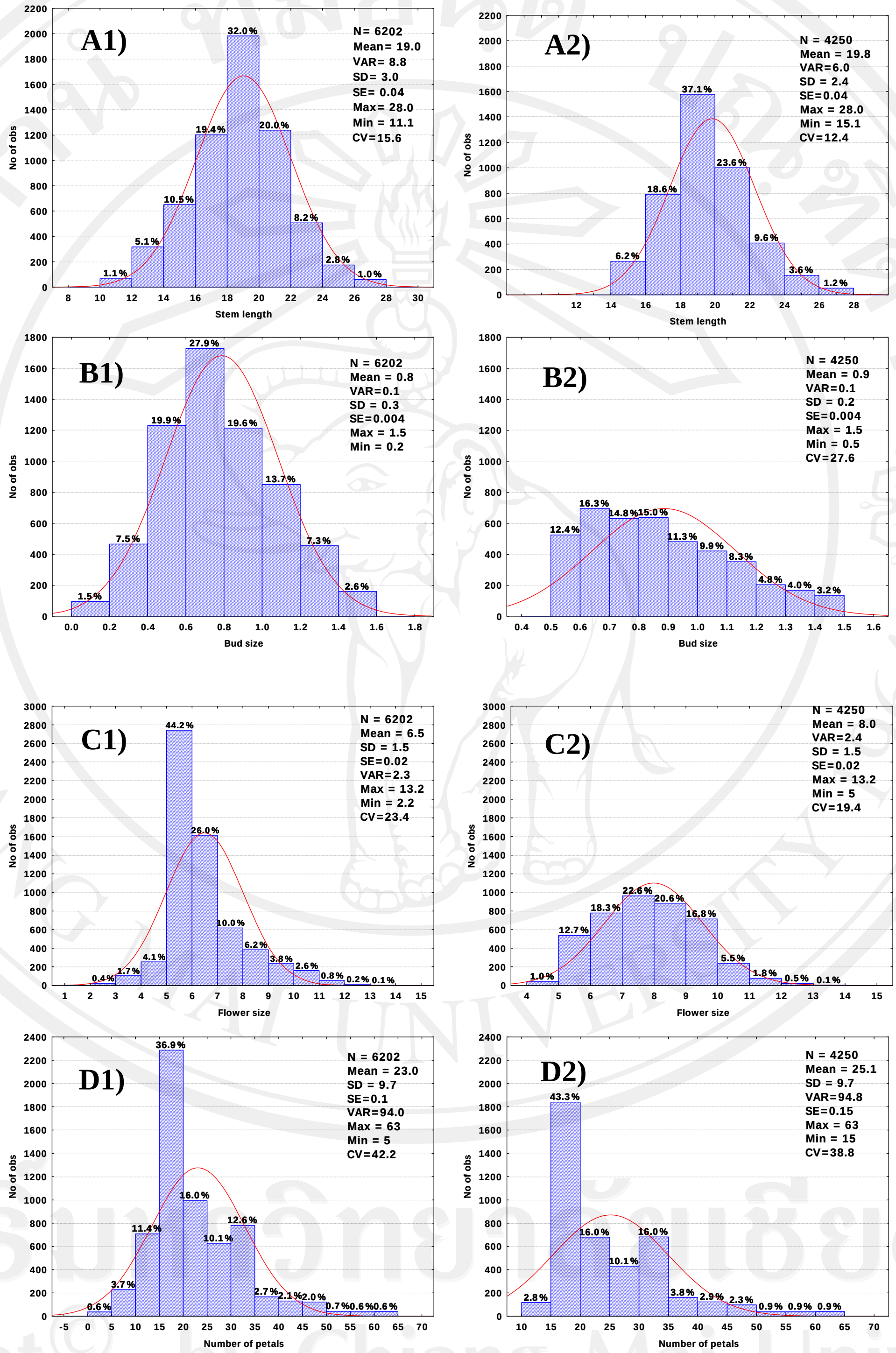


Figure 4.12 The distribution of plants before and after selection at small plant size stage A1-2) Stem length B1-2) Bud size C1-2) Flower size D1-2) Number of petals

4.3.3 Medium plant size stage (6-inch pot)

Design of selection criteria:

The basic information of the sample plants

A sample of 300 rose offspring was randomed to investigate the selection criteria of the discard traits i.e stem length, number of leaves, flower size, flower diameter and number of petals. These traits were conducted from medium to large plant size staged based on the 3 different stem length i.e. short, medium and long and presented in Table 4.15. Stem length gave the different mean value of 2 traits as stem length and bud size.

Table 4.15 Growth of medium plant size before selection from 300 sample plants

Stem length(cm)	Stem length (cm)	Bud size (cm)	Flower size (cm)	Number of petals
Short stem (16-25)	19.2±2.2c	1.7±0.2ab	8.0±1.6	34.0±12.8
Medium stem (26-35)	28.8±2.4b	1.8±0.2a	8.3±1.1	33.7±12.6
Long stem(36-45)	38.7±2.3a	1.8±0.3ab	8.2±1.2	33.9±16.4
Average	28.6±8.4	1.8±0.3	8.2±1.3	33.8±14.0
LSD0.05	0.65	0.07	0.36	3.58
F-test	**	*	ns	ns
CV (%)	8.0	13.5	15.7	37.9

Distribution

Figure 4.13, the normally distributed 6 traits were described, 4 traits were quantitative and 2 traits were qualitative.

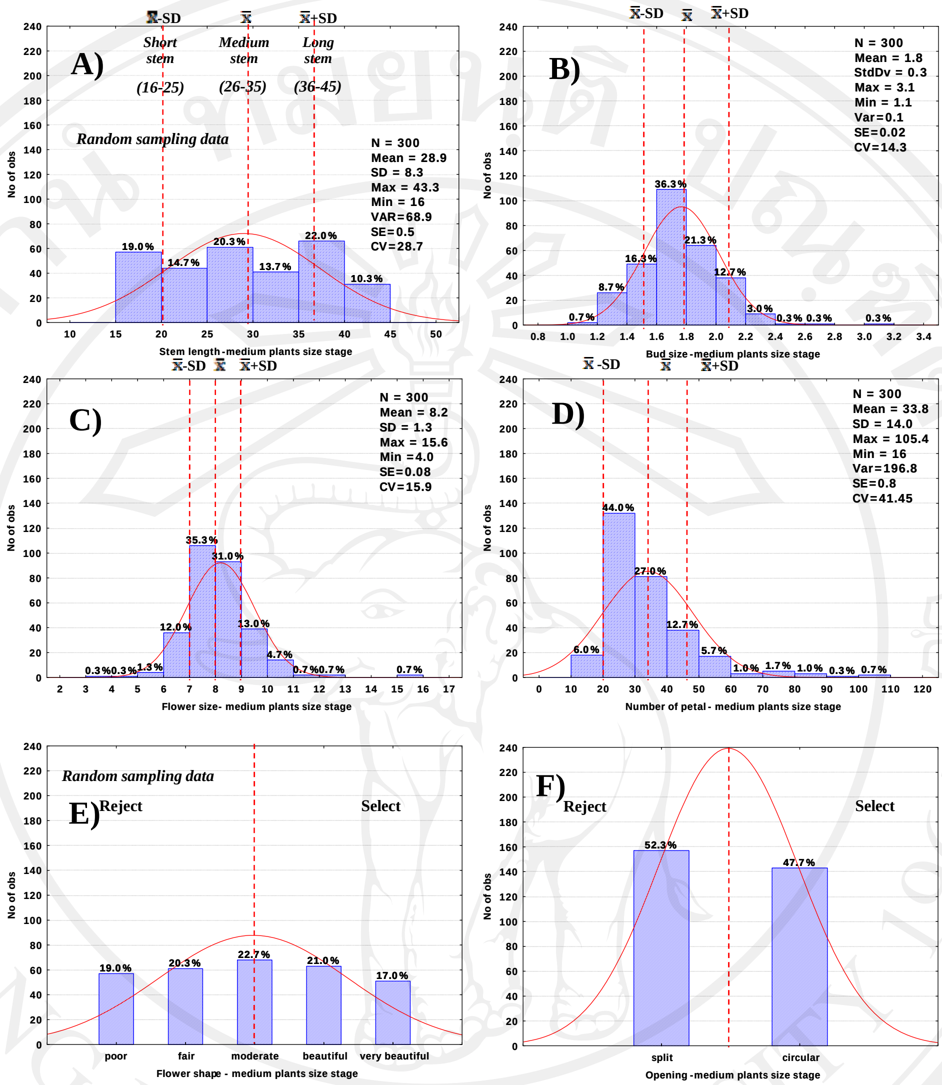


Figure 4.13 The distribution of 300 sample plant at medium plant size stage

A) Stem length B) Bud size C) Flower size

D) Number of petals E) Flower shape F) Opening

The change of traits in next stage

Table 4.16 illustrated growth from different stem lengths. The results showed that different stem lengths gave significant difference of 2 traits in large plant stage but no difference in medium plant size stage.

Table 4.16 Growth of medium to large plant size stage

Stem length (cm)	Characteristics of large plant size stage			
	Stem length (cm)	Bud size (cm)	Flower size (cm)	Number of petals
Short stem (16-25)	62.2±10.1c	2.1±0.2b	9.0±1.1	39.0±11.3
Medium stem (26-35)	74.9±11.6b	2.2±0.3a	9.3±1.6	38.7±13.5
Long stem(36-45)	85.9±11.2a	2.2±0.3ab	9.2±1.2	38.8±16.1
Average	74.3±11.0	2.2±0.3	9.2±1.3	38.8±14.0
LSD0.05	0.81	0.66	0.36	3.57
F-test	**	*	ns	ns
CV (%)	3.95	10.89	14.01	32.92

Distribution

Figure 4.14 presented the normal distritution of 6 traits. Only stem lengths changed in the peak of normal curve. Other traits distributed value on x-axis, except 2 traits of flower quality.

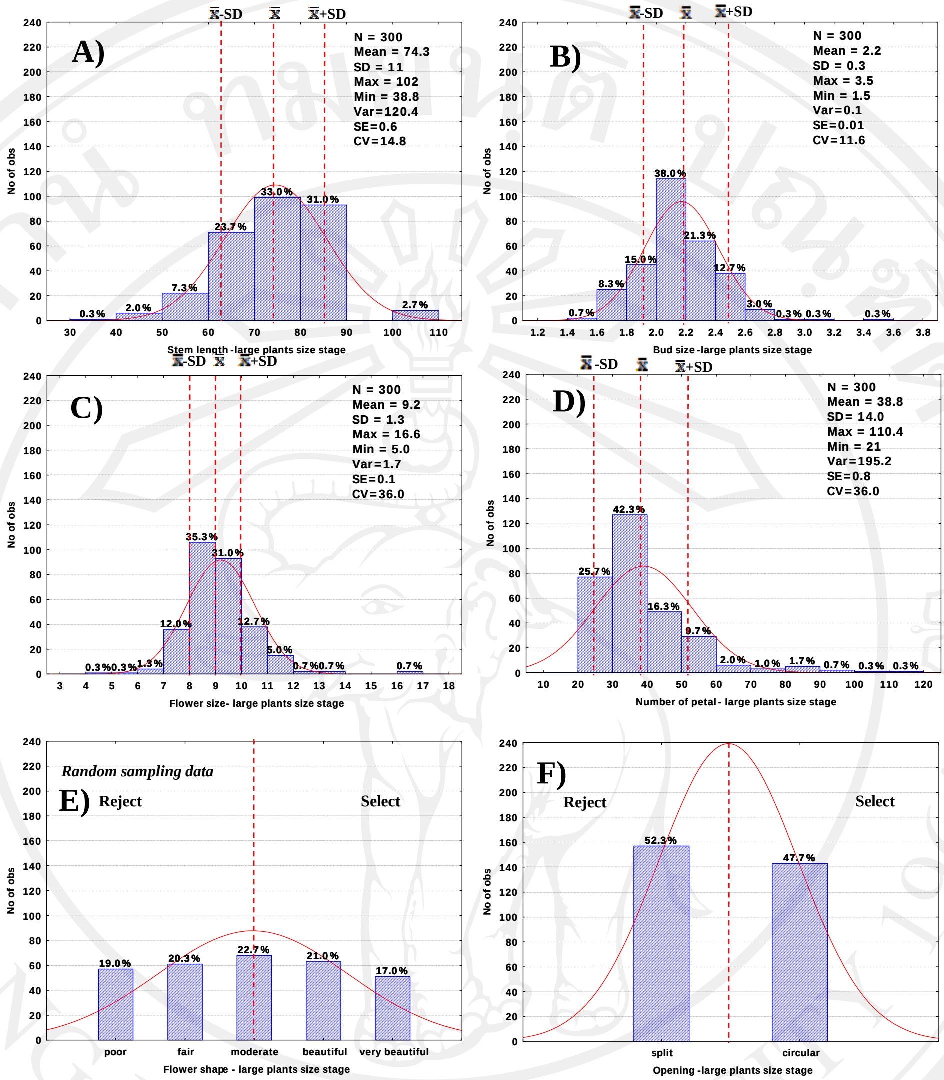


Figure 4.14 The distribution of 300 sample plant at large plant size stage

A) Stem length B) Bud size C) Flower size

D) Number of petals E) Flower shape F) Opening

Correlation between traits and stage of growth

Same traits between stages showed possitive highly significant correlation in stem length, bud size, flower size and number of petals. For between traits within stage, possitive highly significant correlations could be found i.e. bud size – flower size, bud size – number of petals flower size; negative significant correlations were found on the relation of flower – number of petals in both stages. It was concluded that the 2 stages were of close relationship, especially flower characters i.e. bud size, flower size and number of petals, whereas stem length related closely between stages (Table 4.17)

Table 4.17 Correlation between traits and stage of growth

		Stem length		Bud size		Flower size		No. of petals	
		MD	LP	MD	LP	MD	LP	MD	LP
Stem length	MD	1.0							
	LP	0.8**	1.0						
Bud size	MD	0.1	0.1	1.0					
	LP	0.1	0.1	1.0**	1.0				
Flower size	MD	0.1	0.0	0.2**	0.2**	1.0			
	LP	0.1	0.0	0.2**	0.2**	1.0**	1.0		
No. of petals	MD	0.0	0.0	0.3**	0.3**	-0.1*	-0.1*	1.0	
	LP	0.0	0.0	0.3**	0.3**	-0.1*	-0.1*	1.0**	1.0

Note: MD=medium plant size stage, LP= large plant size stage

From Table 4.17, by selecting for one given traits, changes will occurr in other traits, whitch are phenotypically correlated to the trait under selection. Consequently some traits might be changed in correlated traits and were shown both between traits, within stage and between stage (Figure 4.15 – 4.16)

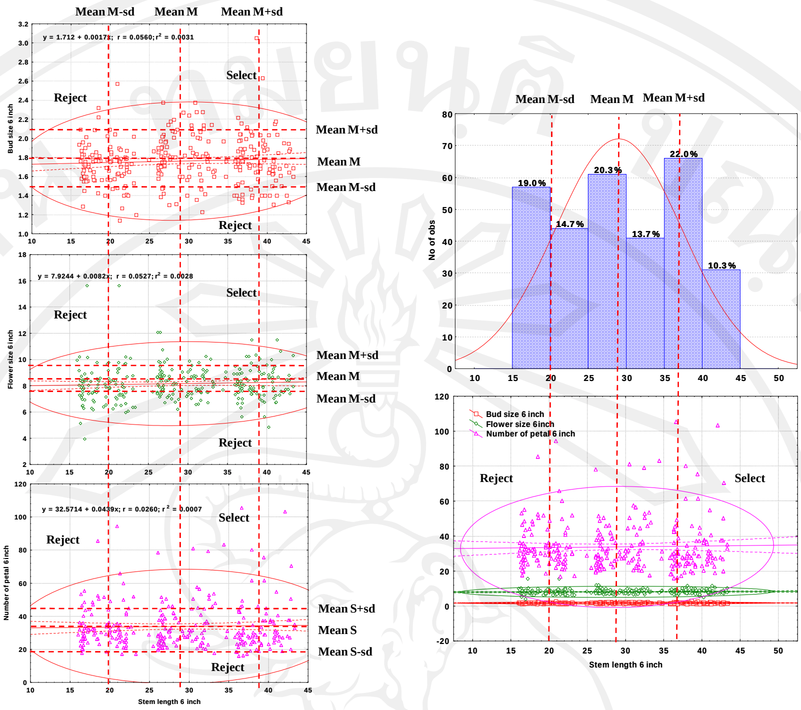


Figure 4.15 Correlation of multi-trait selection at medium plant size stage

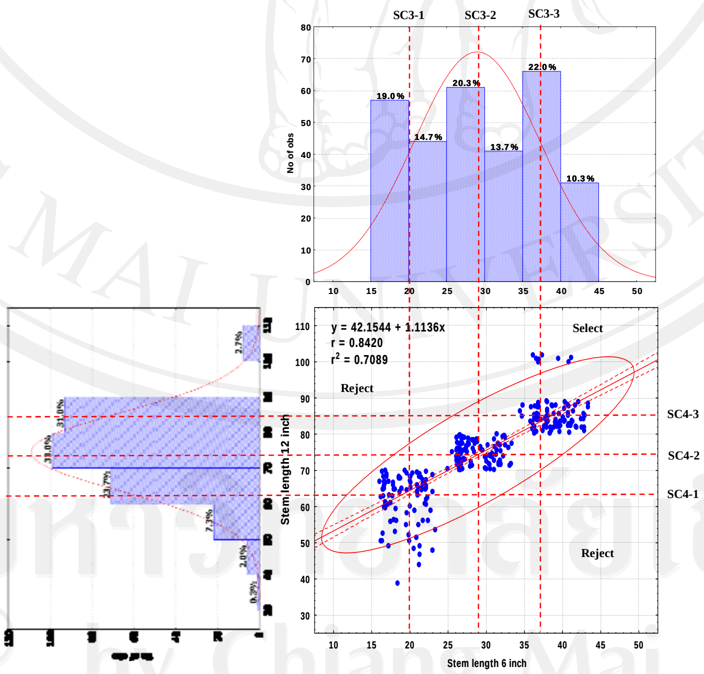


Figure 4.16 Correlation of medium plant size and large plant size at various selections

Interpretation

Table 4.18, the results showed that best criteria for selecting were model 1 because selections were made from the remainder of the first stage which was sufficient for the second stage selection and these plants could also pass the standard of the next phase. It showed that suitable intensity level of selection could be used as criteria for medium and large plant size stages.While model 2 used the high intensity level of selection, the plants passed the standard was therefore not enough for the next stage. Model 3 was not suitable because the intensity level of selection was too high. No passing since the beginning of the first phase. Therefore, model 1 should be used in the selection.

Table 4.18 Simulation model for finding out the optimal intensity of level selection criteria (data of 300 sample individuals)

Model	Variable	SC3=Medium plant size stage criteria						Disc.	SC4=Large plant size stage criteria						Disc.	Total	Remain-ing
		SL	BS	FS	FSH	FO	NP		SL	BS	FS	FSH	FO	NP			
Control	Mean	28.9	1.8	8.2	-	-	33.8	0	74.3	2.2	9.2	-	-	38.8	0	0	300
	SD	8.3	0.3	1.3	-	-	14.0		11.0	0.3	1.3	-	-	13.3			
1	Criteria	20	1.5	7	M	C	20		63	1.9	8	M	C	25			
	Number	57	30	20	70	66	4	247	3	0	0	0	0	0	3	250	50
	SI(%)	19.0	10.0	6.7	23.3	22	1.3	82.3	1.0	0	0	0	0	0	1.0	8303	16.7
	Mean	30.5	1.8	8.6	M	C	32.8		77.7	2.2	9.7	M	C	37.9			
	SD	6.5	0.2	1.1	M	C	13.3		6.4	0.2	1.1	M	C	13.5			
	S	1.6	0	0.4	M	C	-1.0		3.4	0	0.5	M	C	-0.9			
2	Criteria	29	1.8	8	M	C	34		74	2.2	9	M	C	39			
	Number	157	68	32	19	14	8	298	0	0	0	0	0	0	0	298	2
	SI(%)	52.3	22.7	10.7	6.3	4.7	2.6	99.3	0	0	0	0	0	0	0	99.3	0.7
	Mean	34.4	2.1	8.3	M	C	48.1		78.9	2.5	9.3	M	C	53.1			
	SD	5.0	0.3	0.4	M	C	19.1		6.0	0.3	0.4	M	C	19.1			
	S	5.5	0.3	0.1	M	C	14.3		4.6	0.3	0.1	M	C	14.3			
3	Criteria	37	2.1	9	M	C	48		85	2.5	10	M	C	53			
	Number	234	60	3	1	1	1	300	-	-	-	-	-	-	-	-	-
	SI(%)	78.0	20.0	1.0	0.3	0.3	0.3	100	-	-	-	-	-	-	-	-	-
	Mean	37.4	2.1	10.2	M	C	28.0		-	-	-	-	-	-			
	SD	-	-	-	-	-	-		-	-	-	-	-	-			
	S	8.5	0.3	2.0	-	-	-5.8		-	-	-	-	-	-			

Note:SL=stem length, BS=bud size, FS=flower size, FSH=flower shape, FO=opening, NP=number of petals, M= moderate, C=circular

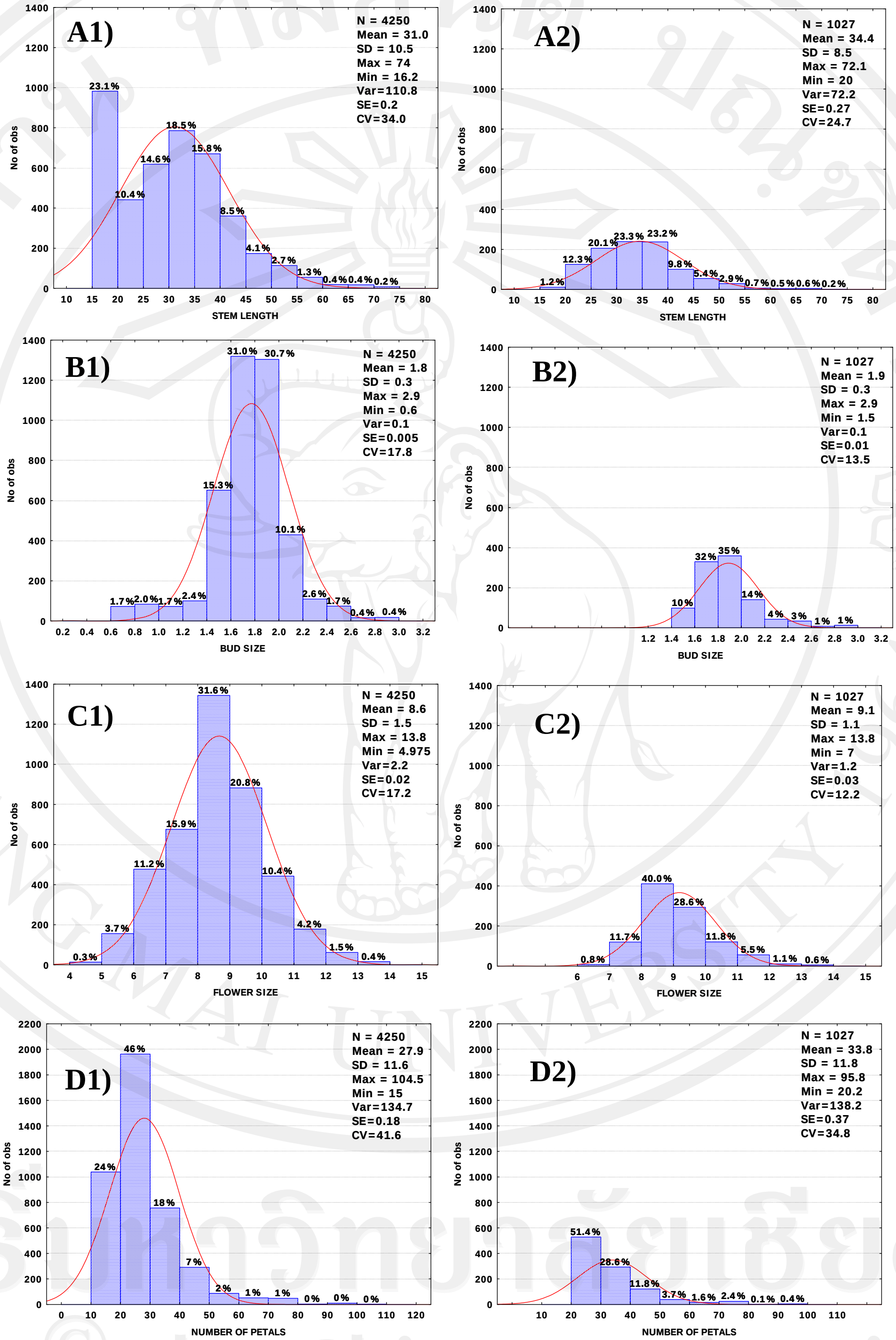
Application of selection methods

At this stage the plants had already had three blooms and approaching 1 year of age. From 4,250 selected plants, discarded ones were as follows: 935 plants with short stem length, 250 plants with bud size less than 1.5 cm, 750 plants with poor flower head shape, 270 plants having blooms with split centers, 382 plants with small flower size, and 636 plants with small number of petals. The remaining 1,027 plants those plants with promising traits (Figure 4.14). At this stage, 24.2% was selected and 75.8% discarded (Table 4.19).

Table 4.19 Plants discarded during medium plant size stage

Characteristics	Discard criteria	Before Selection	Number Discarded	Remaining
Stem length	< 20 cm	4,250	935	3,315
Bud size	< 1.5 cm	3,315	250	3,065
Flower shape	Poor flower head shape	3,065	750	2,315
Opening	Split centers	2,315	270	2,045
Flower size	< 7.0 cm	2,045	382	1,663
Number of petals	< 20 petals	1,663	636	1,027
Total		4,250	3,223	1,027
Percentage		100.0	75.8	24.2

Before and after selection



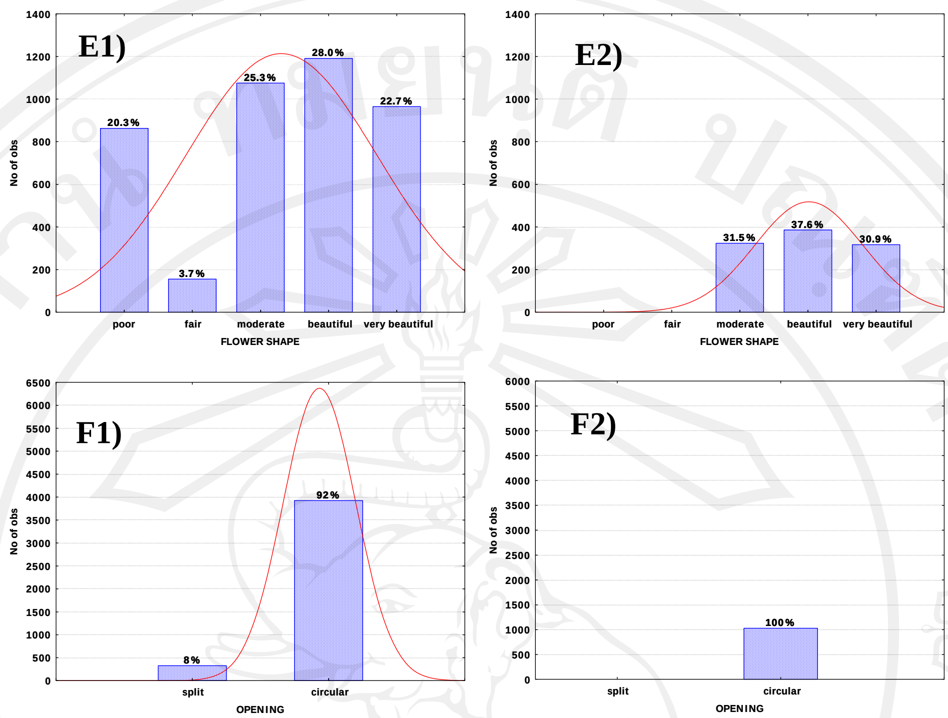


Figure 4.17 Distribution of 150 random sampling data in medium plant size stage (before and after selection)

A1-2) Stem length B1-2) Bud size C1-2) Flower size

D1-2) Number of petals E1-2) Flower shape F1-2) Openning

4.3.4 Large plant size stage (12-inch pot)

The selected plants from the previous stage were potted in 12-inch pots and were now 1-1.5 years old. The 1,027 selected plants were disbudded regularly in order to build the canopy before being allowed to flower after bending technique was practiced. 1027 selected plants were not too many to make records and direct selection without resorting to random sampling

Design of selection criteria:

This stage emphasized productivity and quality traits i.e. stem length, stem size, number of strong cane, and type of rose. Data from 300 sample plants showed some traits which had insignificant difference i.e. bud size, flower size and number of petals. The traits of productivity were calculated and presented were in Table 4.20. For quality traits, type of rose, overall appearance and toughness were scored.

Table 4.20 Descriptive statistics of 1027 selected plants

Characteristics	Mean	Min	Max	Var.	CV.	SE
Stem length	66.4±15.9	30.0	98.8	254.0	24.0	0.50
Stem size	0.9±0.3	0.2	1.5	0.1	39.0	0.01
No. of strong cane	7.4±2.7	2.0	13.0	7.6	37.4	0.09

Correlation between traits

Table 4.21 showed the correlation between traits. Multi-traits could be used as selection criteria.Most productivity traits had significance. Some of the quality traits were important in identifying the type of roses as they were releated to the using purpose and growth habit.

a) Pot roses had short type of bush, small size of stems and large number of strong canes

b) Cut roses had medium-tall type of bush, medium-large size of stems, a large number of strong canes and thick petals. Arching technique could help improve the quality of stems.

c) Garden roses had characters similar to those of cut-roses, except for vigorous bush, soft petals, easy petal dropping, and bent necks

All of these 3 type of roses showed up in the breeding evolution (see litterature review). Breeders should be able to identify the type they were looking for. Bending or arching cultivation technique was one of the means to find a cut-rose because cut-rose should give good response to the bending technique, which rendered high productivity and good quality of stem. The bending technique comprised, firstly, pinching and bending stems to promote strong canes. Strong cane identified the type of roses.

Table 4.21 Correlation between traits of growth

	Stem length	Stem size	Strong cane	Type of rose	Overall apperance	Toughness
Stem length	1.0					
Stem size	0.4**	1.0				
Strong cane	0.2**	0.2**	1.0			
Type of rose	0.3**	0.2**	0.1**	1.0		
Overall Apperance	0.1*	0.0	-0.0	0.2**	1.0	
Toughness	0.0	-0.0	0.0	0.0	0.2**	1.0

Setting up minimum levels:

Selection criteria could be classified into 3 catagories i.e. SC4-1, SC4-2 and SC4-3 from the basic mean ±sd by combining qualitative and quantitative traits. For simplicity, 3D scatterplot showed an example of multi-trait selection based on 3 basic traits (Figure 4.15) i.e. stem length, stem size and number of strong cane. Number of test plant was reduced by discarding worst plants in each trait as shown in Figure 4.18.

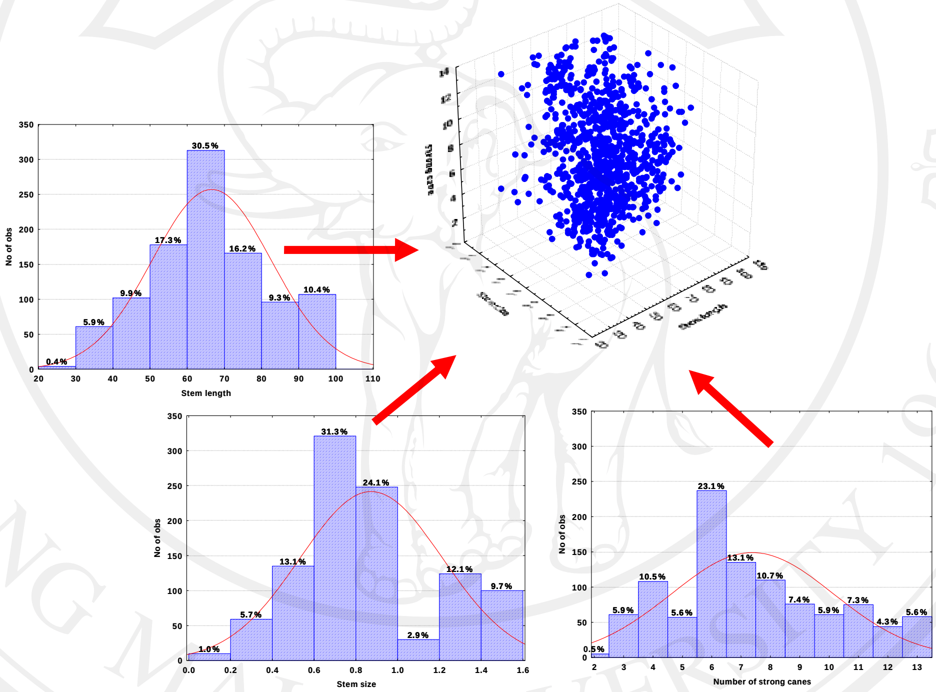
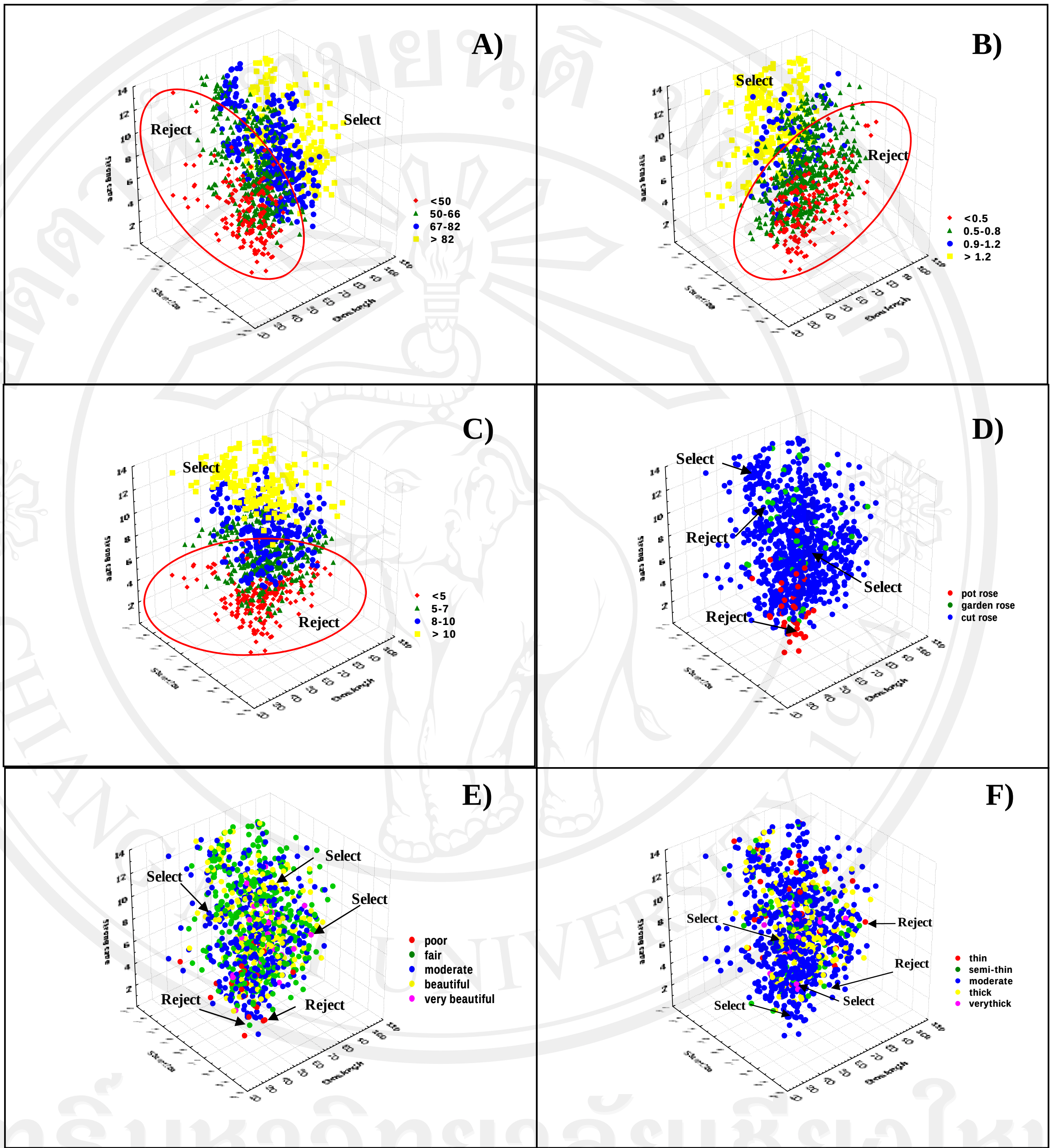


Figure 4.18 3D scatterplot combining 3 traits



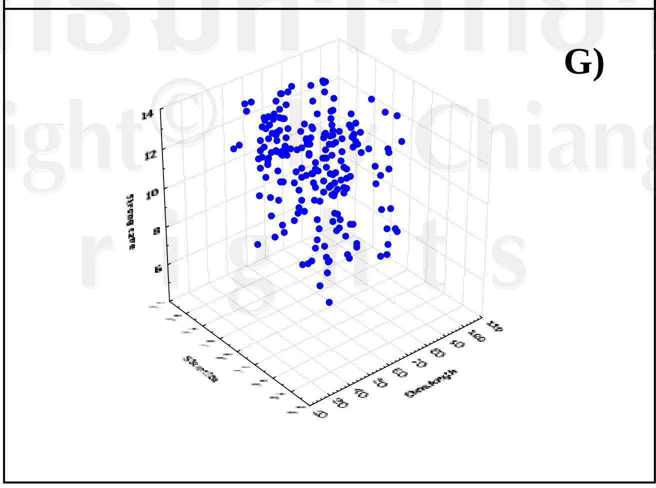


Figure 4.19 3D scatterplot of strong cane against stem length and stem size (one point per one plant)

A) Stem length B) Stem size

C) No. of strong canes D) Type of rose

E) Overall apperance F) Toughness of petals

G) After selection

Interpretation

From Table 4.22, the result showed that model 1 was the best, because number of remaining plants was higher than others. If the selection criteria used only qualitative traits i.e.stem length, stem size and stronge canes, it could reduce the number by 35.2, 84.2 and 97.3%, but combined with quantitative traits it could reduce by 79.7, 92.9 and 98.2%. Rose flower should be of high productivity and beautiful. Breeders should select superior plants with both characters.If the criteria was high selection intensity, the number of plants would be limited.

Table 4.22 Simulation model for finding out the optimal level

Model	Viable	Large size plants stage						Disc.	Remaining
		SL	SS	SC	TR	OA	TP		
Control	Mean	66.4	0.9	7.4	-	-	-	0	0
	SD	15.9	0.3	2.7	-	-	-		
1	Criteria	50	0.5	5	C	M	M		
	Number	153	79	129	27	340	91	819	208
	p (%)	14.9	7.7	12.6	2.6	33.1	8.9	79.7	
	Mean	72.8	1.1	10.4	C	M	M		
	SD	13.0	0.3	2.1	C	M	M		
	S	6.4	0.2	3.0	C	M	M		
2	Criteria	66	0.9	7	C	M	M		
	Number	493	292	80	12	44	33	954	73
	p (%)	48.0	28.4	7.8	1.2	4.3	3.2	92.9	
	Mean	79.3	1.3	10.9	C	M	M		
	SD	11.1	0.2	1.6	C	M	M		
	S	12.9	0.4	3.5	C	M	M		
3	Criteria	82	1.2	10	C	M	M		
	Number	835	106	58	3	3	4	1,009	18
	p (%)	81.3	10.3	5.6	0.3	0.3	0.4	98.2	
	Mean	90.8	1.4	11.5	C	M	M		
	SD	4.3	0.1	1.2	C	M	M		
	S	24.4	0.5	4.1	C	M	M		

Note: SL=stem length, SS=stem size, SC=number of strong canes, TR= type of roses, OA= overall appearance, TP= toughness of petals, Disc=discard

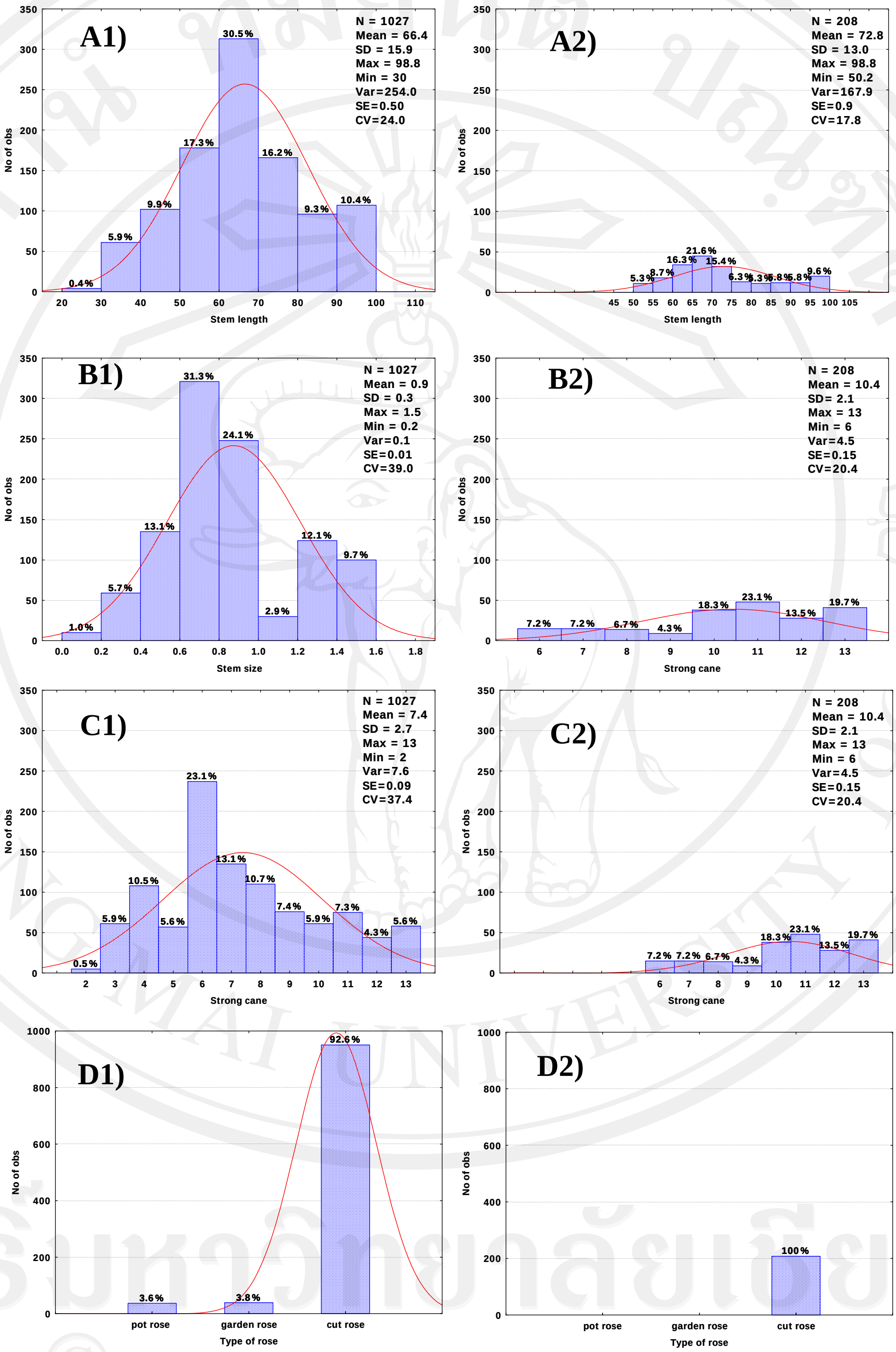
Application of selection methods

The details of the unwanted characters were presented in Table 4.17. At This stage, 79.7% were eliminated and 20.3% were selected and the total number of plants was reduced down to 208 plants.

Table 4.23 Plants discarded during large plants stage

Characteristics	Discard Criteria	Before selection	Number Discarded	Remaining
Stem length	<50 cm	1,027	153	874
- short stem				
- pot rose character				
Stem size	<0.5 cm	874	79	795
- small stem cut rose				
- garden rose character				
Strong cane	<5 stems	795	129	666
-weak cane as a cut rose				
-few strong cane garden rose				
Non cut-rose	Non cut rose	666	27	639
-garden rose				
Overall appearance	Poor	639	340	299
Toughness of petals	Thin petals	299	91	208
Total		1,027	819	208
Percentage		100	79.7	20.3

Before and after selection



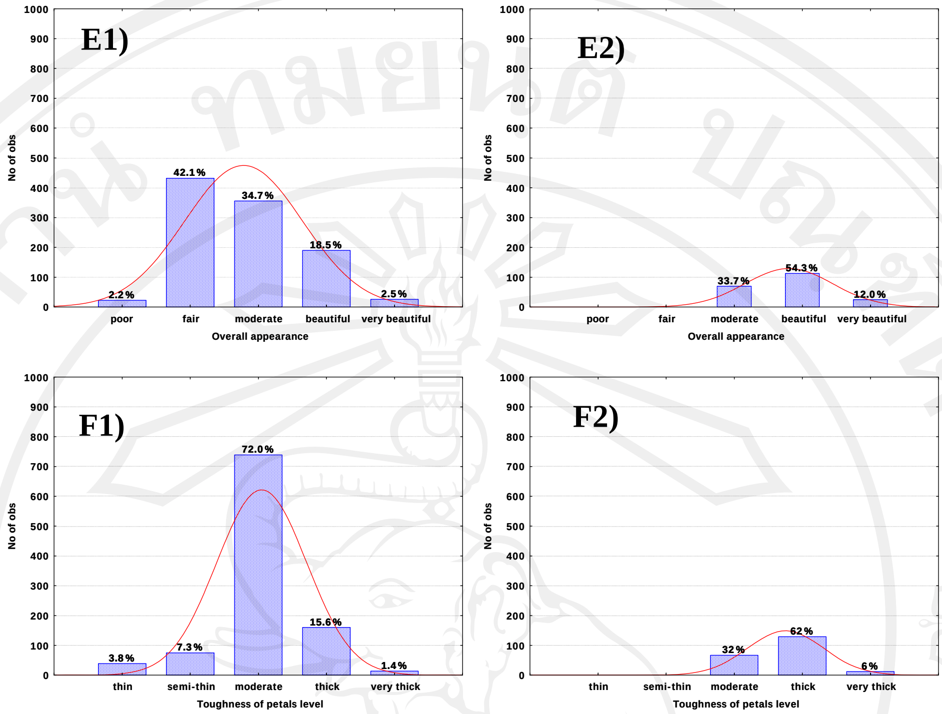


Figure 4.20 the distribution of 150 random sampling data in medium plant size stage (before and after selection)

A1-2) Stem length

B1-2) Stem size

C1-2) Strong cane

D1-2) Type of rose

E1-2) Overall apperance

F1-2) Toughness of petal

4.3.5 First budding stage

After five rounds of selection, the started population had now been much reduced and each selected number needed to be further evaluated in replication.

First budding stage emphasized yield and quality of rose. Therefore, six axillary buds of each selected number were budded on rootstock (*R. multifora*) and accepted cut-rose performance was further evaluated. It took 1 year in order to build up the plants for the precise evaluation. All the tested numbers were compared with the standard variety, 'Dallas'.

Design of selection criteria:

Table 4.24 showed the descriptive statistics of 208 selected plants in first budding stage. The minimum level of growth traits were presented in Table 4.19. The number of petal traits was emphasized in this stage because it was related the opening capability of flowers in different seasons and environment.In general, cut- rose had between 25-75 petals/flowers. The criteria of this stage were designed to eliminate plants lacking or exceeding the value specificed.

Table 4.24 Descriptive statistics of 208 selected plants

Characteristics	Mean	Min	Max	Var.	CV.	SE
Number of flower	15.9±2.9	10.0	25.3	8.7	18.6	0.20
Number of strong cane	8.9±2.0	5.2	14.0	3.9	22.4	0.14
Number of petal	35.6±14.9	15.0	102.8	236.7	40.4	1.07
Stem length	83.4±15.1	46.4	162.3	231.4	18.2	1.05
Bud size	2.1±0.3	1.6	2.9	0.1	10.8	0.02
Flower size	7.5±1.0	5.1	12.0	1.4	14.6	0.08

Correlation between traits

The relationships between traits were presented in Table 4.25. The result showed that significant positive correlations were found in the 6 relations i.e. number of flowers-stem length, number of flower-bud size and number of flowers-flower size, number of strong canes-bud size, number of petals-bud size and bud size and flower size. It could be concluded that the selection of number of petals affected bud size, number of flower and number of strong canes (Figure. 4.21).

Table 4.25 Correlation between growth traits

	No. of flowers	No of Strong canes	No. of petals	Stem length	Bud size	Flower size	Growth type
No. of flower	1.0						
Strong cane	0.1	1.0					
No. of petals	-0.0	-0.1	1.0				
Stem length	0.2*	0.1	-0.1	1.0			
Bud size	0.2*	0.1*	0.4**	0.0	1.0		
Flower size	0.2*	0.1	-0.1	0.0	0.1*	1.0	
Growth type	0.1	-0.0	0.0	-0.0	0.0	-0.0	1.0

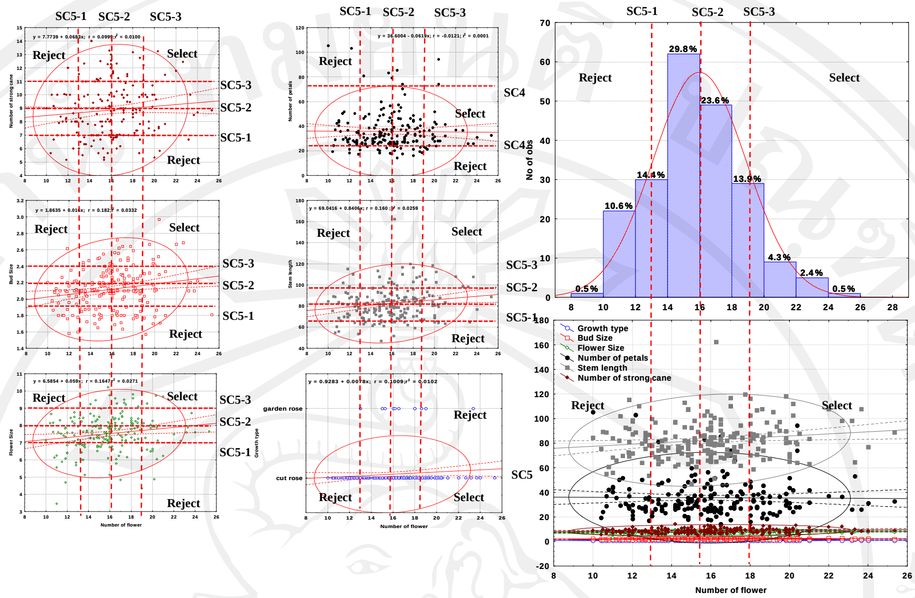


Figure 4.21 Sample of multi-traits correlation at first budding stage

Interpretation

Table 4.26 showed that seven trait criterion could reduce the number of test plants. Growth type of garden roses should be eliminaited, then the productivity be considered. Cut-rose and garden roses were both the hybrid tea rose, with some difference dropping of petals, stability of the flower neck and bush size, etc.

For further identifying, selected plants budded on rootstock would clearly show whether the growth type was the one desired (Figure 4.22)

In the next stage of the plants, after more replication propagation was other aspects must be considered to find out problems on field of each candidate. The results showed that model 1 the most suitable criterion for selection. It gave enough plants to select in the next stage. Model 2 gave a too small number of the remaining plants. Model 3 used too high selection intensity and no plants passed this criteria .So the selection model 1 should be used.

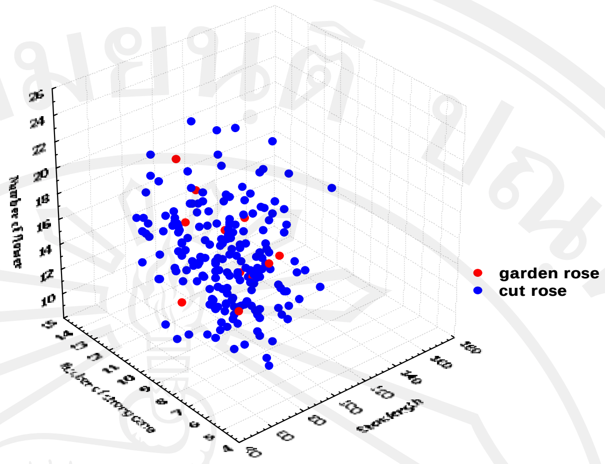


Figure 4.22 Mixed growth habits of garden rose and cut rose

Table 4.26 Simulation model for finding out the optimal level for using as selection criteria

Model	Variable	First budding stage							Disc.	Remaining
		GT	NF	SC	BS	FS	NP	SL		
Control	Mean	-	15.9	8.9	2.1	7.5	35.6	82.4	0	208
	SD	-	2.9	2.0	0.3	1.0	14.9	15.1		
1=SC5-1	Criteria	C	13	7	1.9	7	25-75	67		
	Number	11	35	24	20	22	13	9	134	74
	p (%)	5.3	16.8	11.5	9.6	10.6	6.3	4.3	64.4	35.6
	Mean	-	16.8	9.8	2.2	8.1	36.9	85.7		
	SD	-	2.2	2.0	0.2	0.8	10.8	15.8		
	S		0.9	0.9	0.1	0.6	1.3	3.3		
2=SC5-2	Criteria	C	16	9	2.1	8	25-75	82		
	Number	11	96	51	12	20	0	14	204	4
	p (%)	5.3	46.2	24.5	5.8	9.6	0	6.7	98.1	1.9
	Mean	-	16.8	10.4	2.3	8.2	28.0	110.0		
	SD	-	0.8	1.4	0.2	0.2	2.9	34.7		
	S	-	0.9	1.5	0.2	0.7	-7.6	27.6		
3=SC5-3	Criteria	C	19	11	2.4	9	25-75	98		
	Number	11	169	22	3	2	0	1	208	0
	p (%)	5.3	81.3	10.6	1.4	1.0	0	0.5	100.0	0
	Mean	-	-	-	-	-	-	-	-	
	SD	-	-	-	-	-	-	-	-	
	S	-	-	-	-	-	-	-	-	

Note: GT=growth type, NF=number of flowers, SC=number of strong cane, BS=budding size, FS=flower size, NP=number of petals, SL=stem length, Disc=discarded

Application of selection methods

Characters for discard were as follows:

a.) plants with garden rose type

b.) small number of flowers/plant (<13)

c.) small number of strong canes (< 7)

d.) number of petals less than 25 and more than 75

e.) unopen flower bud with diameter less than 2.0 cm

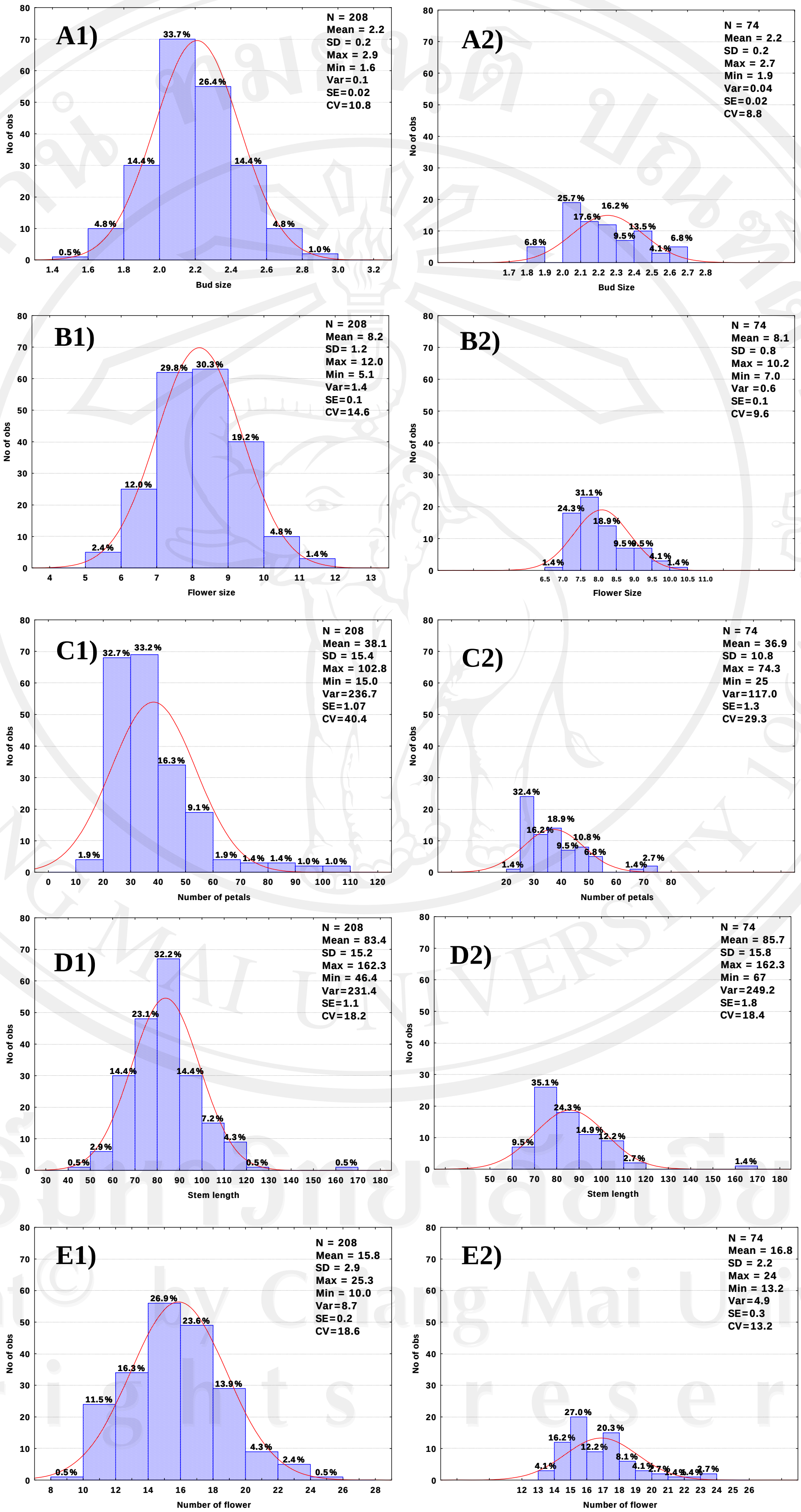
f.) fully open flower with diameter less than 7.0 cm

Of the 208 number, 74 numbers with good characters were selected for further round of evaluation. At this stage, 64.4% was discarded and 35.6% selected (Table 4.27 and Figure 4.22)

Table 4.27 Plants discarded during first budding stage

Characteristics	Discarded Criteria	Before selection	Number Discarded	Remaining
Growth type	Garden rose habit	208	11	197
Number of flowers	<13 stems/plants	197	35	162
Number of strong canes	<7 stems/plants	162	24	138
Bud size	<1.9cm	138	20	118
Flower size	<7 cm	118	22	96
Number of petals	<25 or >75 petals	96	13	83
Stem length	<67 cm	83	9	74
Total		208	134	74
Percentage		100.0	64.4	35.6

Before and after selection



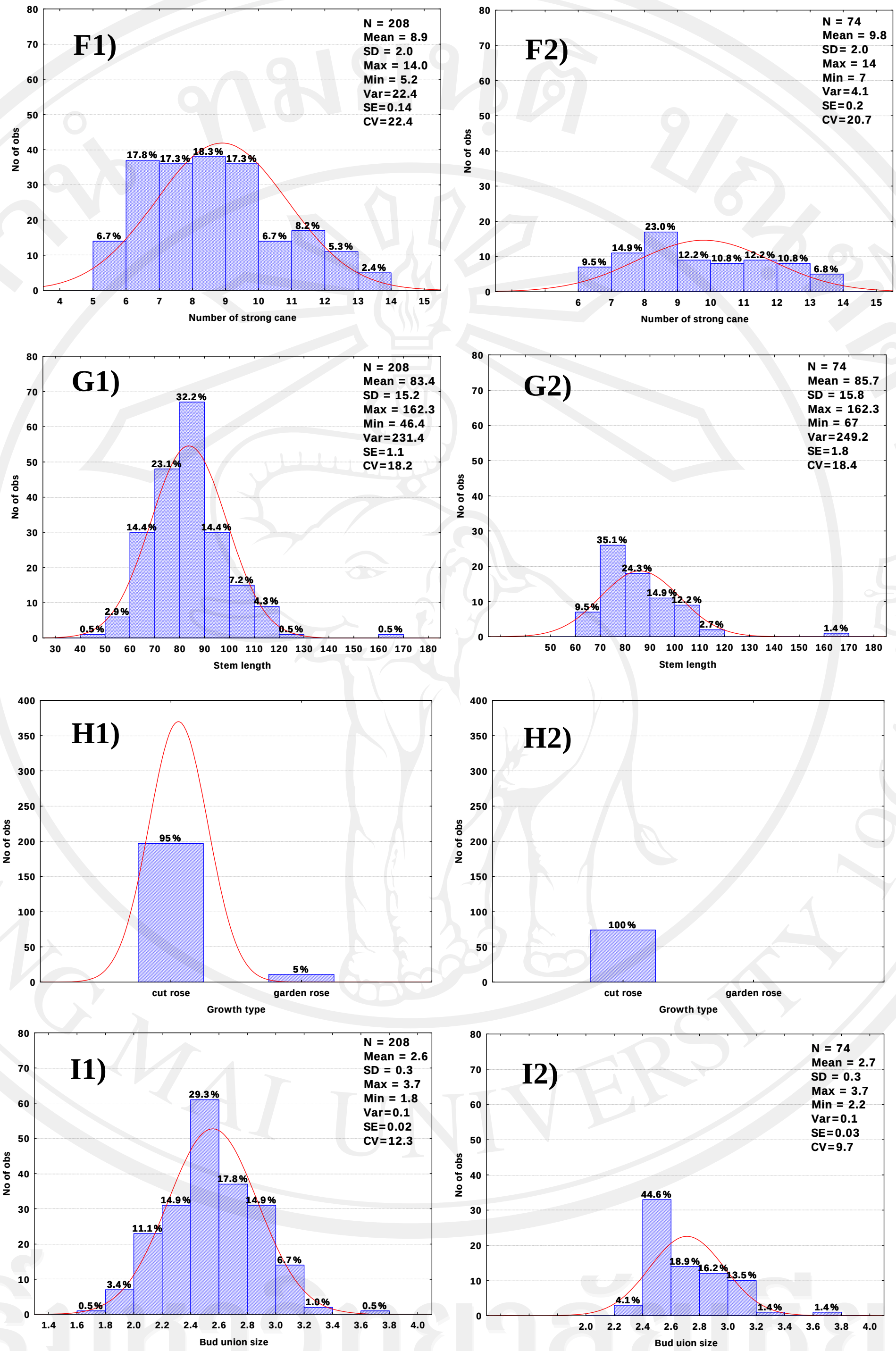


Figure 4.23 Distribution before and after, as affected by criteria

A1-2) Bud size	B1-2) Flower size	C1-2) Number of petals
D1-2) Stem length	E1-2) Number of flower	F1-2) Number of strong canes
G1-2) Stem length	H1-2) Growth type	I1-2) Bud union size

4.3.6 Second Budding Stage

The 74 selected numbers now needed to be observed in a higher number of population. Therefore 24 axillary buds were budded on rootstock (*R. multifora*). This population was again compared with the standard variety (Dallas) and was further evaluated for 1 year.

Design of selection criteria:

Table 4.28 showed the descriptive statistics for formulating selection criteria from 74 selected plants data.Two periods of selection were established, i.e.first period to consider the flower character traits and next period to conduct the efficiency of production i.e. grade, productivity, flush and problems found in production fields. Because the plants in this stage were fully grown, the flowers therefore had most of the characteristics (see the change of characteristics), especially larger flower size, greater good grades (more number of strong canes), but the number of flowers was fewer and bud union smaller than the first budding stage. This could be explained that these plants increased the quality and size of flowers before they developed the number of flower and bud union.

Table 4.28 Descriptive statistics of 74 selected plants

Characteristics	Mean	Min	Max	Var.	CV.	SE
Bud size	2.7±0.5	1.9	3.9	0.3	18.8	0.06
Flower size	10.5±1.9	7.4	16.1	3.8	18.4	0.23
Number of petals	38.6±13.0	19.4	74.9	170.1	33.8	1.52
Stem length	80.1±12.9	46.4	133.1	228.0	17.5	1.76
Bud union	2.6±0.3	1.8	3.7	0.1	13.0	0.04

Correlation between traits

Table 4.29, Possively correlations were found as follows: bud size-flower size, bud size-number of petals, bud size and stem length, flower size-number of petals and stem length-bud union. The correlation between bud size and other traits was significant; it was possible to reduce the number of test plants by considering the flower characteristics (Figure 4.24).

Table 4.29 Correlation of various traits in second budding stage

	Bud size	Flower size	No. of petals	Stem length	Bud union
Bud size	1.0				
Flower size	0.7**	1.0			
No. of petals	0.4**	0.2*	1.0		
Stem length	0.3*	0.2	-0.0	1.0	
Bud union	0.2	0.2*	-0.1	0.3*	1.0

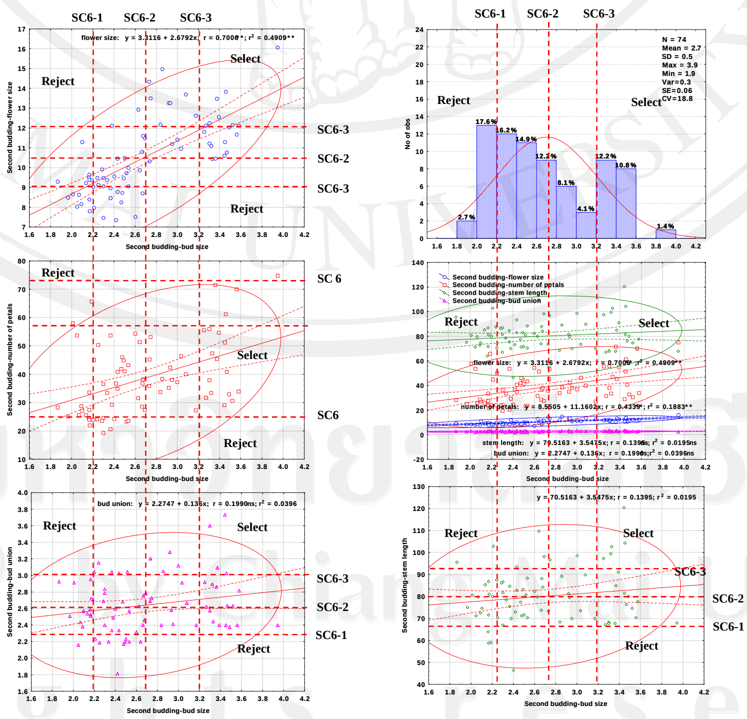


Figure 4.24 Sample of multi-traits correlation at second budding stage

Interpretation

Table 4.30 demonstrated that model 1 was the best model for selection having largest numbers of plants, while the 2 remaining models had too small number of plants for the next selection. Due to the fact that yield and quality evaluation had to be made for the filed production. Saleable roses were judged from beautiful flowers, high productivity, good quality of yield, and less problems in field production For the next phase, the selection by independent culling level method should combine the scoring methods. The final total scores were compared for all characteristics with standard check varieties.

Table 4.30 Simulation model for finding out the optimal level

Model	Viable	Secone budding stage					Disc.	Remaining
		BS	FS	NP	SL	BUS		
Control	Mean	2.7	10.5	38.6	80.1	2.6	0	0
	SD	0.5	1.9	13.0	12.9	0.3		
1	Criteria	2.2	9	25-75	67	2.3		
	Number	8	11	11	3	7	40	34
	p (%)	10.8	14.9	14.9	4.1	9.5	54.1	45.9
	Mean	3.1	12.3	42.4	82.2	2.7		
	SD	0.4	1.3	13.1	13.5	0.3		
	S	0.4	1.8	3.8	2.1	0.1		
2	Criteria	2.7	11	25-75	80	2.6		
	Number	40	7	0	14	3	64	10
	p (%)	54.1	9.5	0	18.9	4.1	86.5	13.5
	Mean	3.0	12.9	42.7	94.0	3.1		
	SD	0.2	1.3	10.8	7.3	0.3		
	S	0.3	2.4	4.1	13.9	0.5		
3	Criteria	3.2	12	25-75	93	3.0		
	Number	55	9	0	8	1	73	1
	p (%)	74.3	12.2	0	10.8	1.4	98.6	1.4
	Mean	3.5	13.8	61.2	104.3	3.0		
	SD	-	-	-	-	-		
	S	0.8	3.3	22.6	24.2	0.4		

Note: BS=bud size, FS=flower size, NP=number of petals, SL=stem length, BUS= bud union size

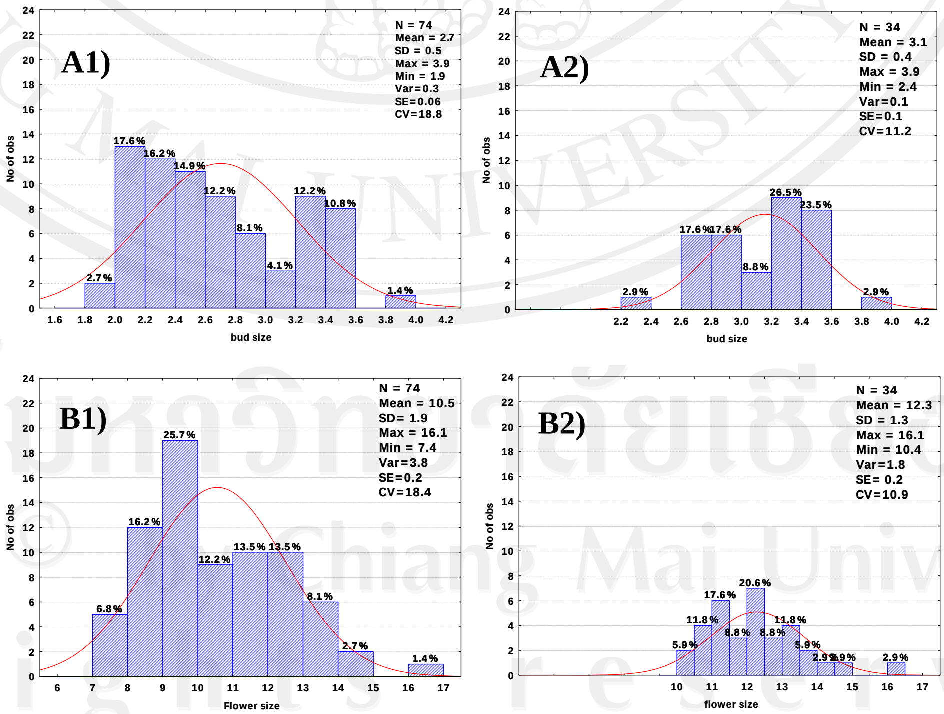
Application of selection methods

The details of the unwanted characters were presented in Table 4.31. At this stage, 54.1% was eliminated and 45.9% selected, leaving 34 plants to be further selected for yield and quality traits.

Table 4.31 Plants discarded during first budding stage

Characteristics	Discarded Criteria	Before selection	Number Discarded	Remaining
Bud size	<2.2 cm	74	8	66
Flower size	<9 cm	66	11	55
Number of petals	<25 or >75 petals	55	11	44
Stem length	<67 cm	44	3	41
Bud union	<2.4	41	7	34
Total		74	40	34
Percentage		100	54.1	45.9

Before and after selection



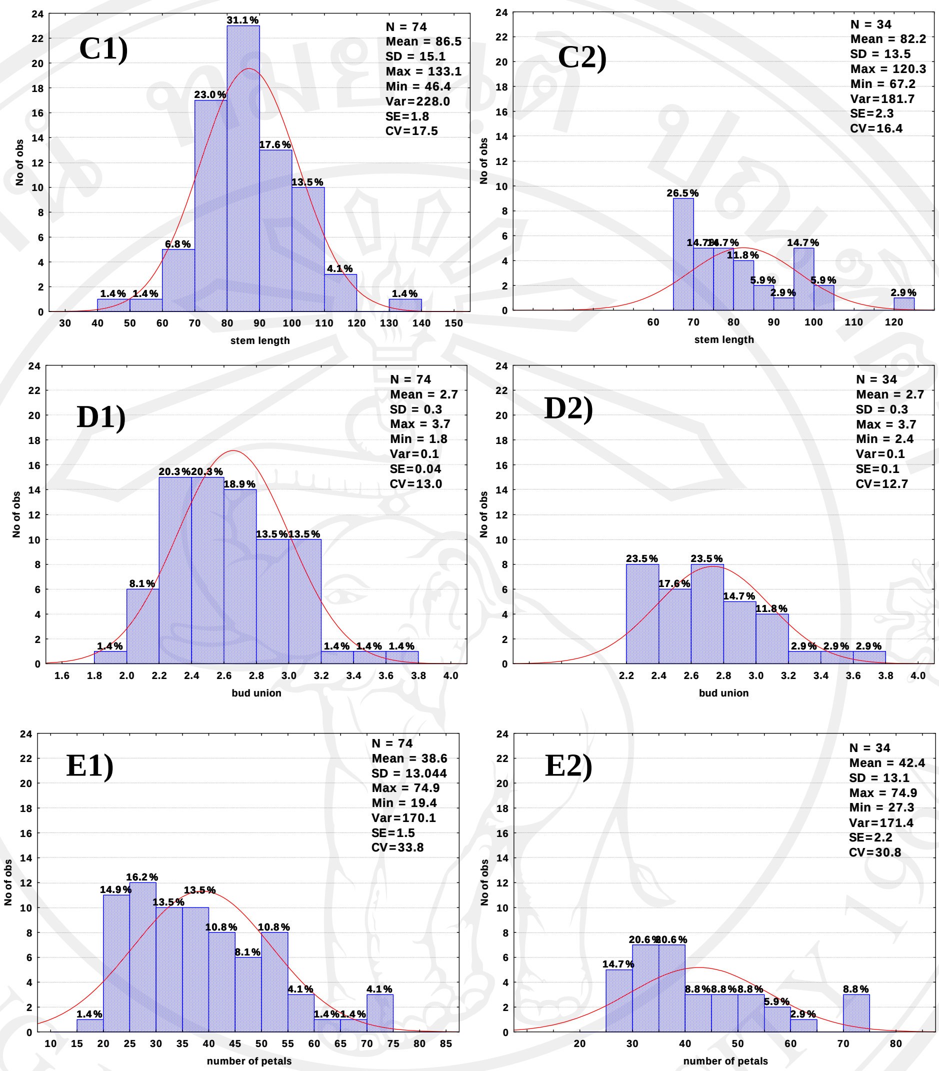


Figure 4.25 Distribution before and after, as affected by criteria

A1-2) Bud size B1-2) Flower size C1-2) Stem length

D1-2) Bud union size E1-2) Number of petals

The Change of Characteristics

1. Original plants and first budded clones

After 1 year, budded plants showed better growth than the original plants in every characteristic, especially stem length, number of petals and number of flowers (Table 4.32). The results showed that the first budding improved all characteristics because budded plants had stronger root system and gave better results than the original plants both quantitatively and qualitatively. Almost all characteristics had high positive correlation between traits and stages of growth (Table 4.34). Rose breeders could predict their further traits from the equation provided in Table 4.33.

Table 4.32 Comparison of seven traits of selected original plants and their first budded plants

	Bud size	Flower size	No. of petals	Stem length	No.of Strong cane	No.of flower	Bud union size
Original plants	2.0±0.2a	7.3±1.1a	32.3±12.9a	66.2±15.1a	6.8±1.2a	11.4±2.0a	2.4±0.3a
First budding	2.2±0.2b	8.2±1.2b	38.1±15.4b	83.4±15.2b	8.9±2.0b	15.8±2.9b	2.6±03b
Diff.	0.2	0.8	5.8	17.2	2.0	4.4	0.2
t-value	-8.4**	-7.5**	-4.1**	-11.6**	-12.6**	-17.8**	-6.3**
Correlation	0.73**	0.75**	0.81**	0.46**	0.54**	0.74**	0.72**

*Note:*t-values of test for difference of mean,* or **, n=208, significant at p=.05 or p=.01

Table 4.33 Prediction formula from the relation between the original and first budded plants

Characteristics	Predicted formula	Regression	P-value
Bud size	y=0.413+0.885x	r^2=0.5287**	p=0.0000
Flower size	y=2.0099+0.8394x	r^2=0.5577**	p=0.0000
Number of petals	y=7.0535+0.9602x	r^2=0.6516**	p=0.0000
Stem length	y=52.711+0.464x	r^2=0.2127**	p=0.0000
No. of strong cane	y=2.94.08+0.8673x	r^2=0.2929**	p=0.0000
No. of flower/plants	y=3.4994+1.08x	r^2=0.5457**	p=0.0000
Bud union size	y=0.6806+0.761x	r^2=0.5212**	p=0.0000

Table 4.34 Coefficients of correlation between the characteristics of 208 selected offspring, on their second budded plants.

Characteristics		1		2		3		4		5		6		7	
		O	FB	O	FB	O	FB	O	FB	O	FB	O	FB	O	FB
1. Bud size	O	1.0													
	FB	0.7**	1.0												
2.Flower size	O	0.2*	0.1	1.0											
	FB	0.2*	0.2**	0.8**	1.0										
3.No. of petals	O	0.3**	0.3**	-0.1	-0.2*	1.0									
	FB	0.4**	0.5**	-0.2	-0.1	0.8**	1.0								
4.Stem length	O	-0.1	-0.3**	-0.1	-0.3	-0.0	-0.1	1.0							
	FB	0.1	-0.0	-0.0	-0.0	-0.1	-0.1	0.5**	1.0						
5.No. of Strong canes	O	-0.1	-0.1	0.2*	0.1	-0.1	-0.1	-0.1	-0.0	1.0					
	FB	0.1	0.1	0.2*	0.2*	-0.1	-0.1	-0.2**	0.1	0.5**	1.0				
6.No. of f lowers	O	0.0	0.1	0.1	0.1	0.1	-0.1	0.1	-0.0	0.3**	0.1	1.0			
	FB	0.1	0.1	0.1	0.1	-0.1	-0.0	-0.1	0.1	0.2**	0.1	0.7**	1.0		
7.Bud union size	O	0.0	0.0	-0.1	0.0	-0.1	-0.0	0.1	0.1	0.2**	0.2**	0.1	0.2**	1.0	
	FB	0.1	0.0	-0.0	0.1	-0.1	-0.0	-0.0	0.1	0.2*	0.2**	0.1	0.2**	0.7**	1.0

Note: n = 208 * significances at p≤0.05, ** highly significances at p≤0.01; O = Original plants, FB=First budding plants

2. Original plants and second budded clones

Clonal plants had better growth and development than original plants in every characteristic. Highly positivly significance was found on the characteristics traits of flower size, number of petals, stem length, number of strong canes and number of flowers.It was concluded that some traits of the second budded plants could not be predicted from the original traits (Table 4.35). The 7 prediction formulas on the relation between the original plants and those grown on rootstock (clonal plants) were presented; two of the seven equations were significant (Table 4.36) and 18 significant correlations were found (Table 4.37).

Table 4.35 Comparison of seven traits of selected original plants and their first budded plants

	Bud size	Flower size	No. of petals	Stem length	No.of strong cane	No.of flower	Bud union size
Original plants	2.1±0.2b	7.7±1.0b	31.6±9.5b	53.9±10.4b	7.1±1.3b	11.1±1.7b	2.5±0.3b
Second budded	2.7±0.5a	10.5±1.9a	38.6±13.0a	80.1±12.9a	10.1±1.8a	13.5±2.0a	2.6±0.3a
Diff.	0.6	2.8	7.0	26.1	2.9	2.3	0.2
t-value	-9.8**	-11.3**	-3.7**	-13.5**	11.6**	-7.8**	-3.3**
Correlation	0.09ns	0.19ns	0.77**	0.12ns	0.25*	0.08ns	0.68**

*Note:*t-values of test for difference of mean,* or **, n=74, significant at p=.05 or p=.01

Table 4.36 Prediction formula on the relation between the original plants and clonal plants

Characteristics	Prediction formula	Regression	P-value
Bud size	y=2.2553+0.2119x	r^2=0.0073ns	p=0.4706
Flower size	y=7.5467+0.3876x	r^2=0.0363ns	p=0.1040
Number of petals	y=5.2421+1.0548x	r^2=0.5896**	p=0.0000
Stem length	y=72.3098+0.1439x	r^2=0.0136ns	p=0.3226
No. of strong cane	y=7.5315+0.3541x	r^2=0.0646ns	p=0.0288
No. of flower/plants	y=12.3956+0.0966x	r^2=0.0066ns	p=0.4906
Bud union size	y=0.7474+0.7687x	r^2=0.4619**	p=0.0000

Table 4.37 Coefficients of correlation between the characteristics of 74 selected offspring, on their second budded plants.

Characteristics		1		2		3		4		5		6		7	
		O	SB	O	SB	O	SB	O	SB	O	SB	O	SB	O	SB
1. Bud size	O	1.0													
	SB	0.1	1.0												
2.Flower size	O	0.1	0.0	1.0											
	SB	-0.2	0.7**	0.2	1.0										
3.No. of petals	O	0.3**	0.2	0.2*	0.1	1.0									
	SB	0.3*	0.4**	0.2	0.3*	0.8**	1.0								
4.Stem length	O	-0.1	-0.0	-0.1	0.1	-0.1	-0.1	1.0							
	SB	0.0	0.1	-0.3*	0.1	-0.1	-0.0	0.1	1.0						
5.No. of strong canes	O	-0.1	0.2	0.3*	0.1	0.3*	0.3**	-0.1	-0.1	1.0					
	SB	-0.0	0.0	0.1	0.0	0.2	0.1	0.0	0.1	0.3*	1.0				
6.No. of f lowers	O	-0.1	0.1	0.2	0.0	0.2	0.1	-0.1	-0.0	0.3*	0.7**	1.0			
	SB	0.1	0.0	-0.2	-0.0	0.0	0.0	-0.2	0.0	0.1	0.3*	0.1	1.0		
7.Bud union size	O	0.0	0.1	-0.0	0.2	-0.2	-0.2	0.2	0.3**	0.1	0.1	0.1	-0.0	1.0	
	SB	-0.1	0.2	0.1	0.3*	-0.1	-0.1	0.2	0.2	0.1	0.1	0.1	-0.1	0.7*	1.0

Note: n = 74 * significances at p≤0.05, ** highly significances at p≤0.01; O = Original plants, FB=First budded plants, SB=Second budded plants

2. First budded and second budded clones

Table 4.38 showed that almost all characteristics had different means between first and second budding, except stem length. Correlations and regression between traits and stages were presented in Table 4.38-4.39. It was found that 2 traits i.e. flower size and number of flowers had no significance.18 correlations were also significant (Table 4.40).

Table 4.38 Comparison of seven traits of selected original plants and their first budded plants

	Bud size	Flower size	No. of petals	Stem length	No.of strong cane	No.of flower	Bud union size
First budding	2.2±0.2b	7.9±0.7b	34.3±9.1b	83.2±17.2	7.2±1.4b	16.5±2.8a	2.8±0.4a
Second budding	2.7±0.5a	10.5±1.9a	38.6±13.0a	80.1±12.9	10.1±1.8a	13.5±2.0b	2.6±0.3b
Diff.	0.5	2.6	4.3	3.2	2.8	3.0	0.1
t-value	-7.6**	-11.0**	-2.3**	1.3ns	-10.8**	2.2*	7.4**
Correlation	0.29*	0.11ns	0.78**	0.87**	0.47**	0.05ns	0.71**

*Note:*t-values of test for difference of mean,* or **, n=74, significant at p=.05 or p=.01

The 7 prediction formulas on the relation between the original plants and those grown on rootstock (clonal plants) were as follows:

Table 4.39 Prediction formula on the relation between the first and second budded plants

Characteristics	Prediction formula	Regression	P-value
Bud size	y=0.974+0.7761x	r^2=0.0854*	p=0.0115
Flower size	y=8.188+0.2968x	r^2=0.3435ns	p=0.3435
Number of petals	y=0.316+1.1158x	r^2=0.6107**	p=0.0000
Stem length	y=25.9394+0.6503x	r^2=0.7510**	p=0.0000
No. of strong canes	y=5.774+0.5911x	r^2=0.2183**	p=0.00003
No. of flower/plants	y=12.898+0.0348x	r^2=0.0025ns	p=0.6707
Bud union size	y=0.9279+0.6174x	r^2=0.4989**	p=0.0000

Table 4.40 Coefficients of correlation between the characteristics of 74 selected first budded, and second budded plants.

Characteristics		1		2		3		4		5		6		7	
		FB	SB	FB	SB	FB	SB	FB	SB	FB	SB	FB	SB	FB	SB
1. Bud size	FB	1.0													
	SB	0.1	1.0												
2.Flower size	FB	0.1	0.0	1.0											
	SB	-0.2	0.7**	0.2	1.0										
3.No. of petals	FB	0.3**	0.2	0.2*	0.1	1.0									
	SB	0.3*	0.4**	0.2	0.2*	0.8**	1.0								
4.Stem length	FB	-0.1	-0.0	-0.1	0.1	-0.1	-0.1	1.0							
	SB	0.0	0.1	-0.3*	0.1	-0.1	-0.0	0.1	1.0						
5.No. of Strong canes	FB	-0.1	0.2	0.3*	0.1	0.3*	0.3*	-0.1	-0.1	1.0					
	SB	-0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.1	0.3*	1.0				
6.No. of f lowers	FB	-0.1	0.1	0.2	0.0	0.2	0.1	-0.1	-0.0	0.3*	0.7**	1.0			
	SB	0.1	0.0	-0.2	-0.0	0.0	0.0	-0.2	0.0	0.1	0.3*	0.1	1.0		
7.Bud union size	FB	0.0	0.1	-0.0	0.2	-0.2	-0.2	0.2	0.3*	0.1	0.1	0.1	-0.0	1.0	
	SB	-0.1	0.2	0.1	0.2*	-0.1	-0.1	0.2	0.2	0.1	0.1	0.1	-0.1	0.7**	1.0

Note: n = 74 * significances at $p \leq 0.05$, ** high significances at $p \leq 0.01$; O = Original plants, FB=First budded plants, SB=Second budded plants

3. Original plants and their budded plants

Most characteristics of first and second budded clones were different from original plants, while those of first and second budded plants also were different, exspecially in the number of flower/plants and flower size. First budded plants gave better number of flowers, but second budded plants gave better flower size (Table 4.41). The 7 prediction formular on the relation between the original plants and their budded plants could be predicted by multiple regressions (Table 4.42). The correlations between 7 traits also were present in table 4.43.

Table 4.41 Comparison of seven traits of selected original plants and their budded plants

	Bud size	Flower size	No. of petals	Stem length	No.of strong cane	No.of flower	Bud union size
Original plants	2.1+1.6c	7.7+1.0b	31.6+9.5c	53.9+10.4b	7.1+1.3b	11.1+1.7b	2.5+0.3b
First budding	2.2±0.2b	7.9±0.7ab	34.3±9.1b	83.2±17.2a	7.2±1.4b	16.5±2.8a	2.8±0.4a
Second budding	2.7±0.5a	10.5±1.9a	38.6±13.0a	80.1±12.9ab	10.1±1.8a	13.5±2.0ab	2.6±0.3b
F-test	**	**	**	**	**	**	**
Corelation	0.09ns	0.04ns	0.82**	0.87**	0.47**	0.08ns	0.804**

*Note:*t-values of test for difference of mean,* or **, n=74, significant at p=.05 or p=.01

Table 4.42 Prediction formula on the relation between the first and second budded plants

Characteristics	Predicted formula	Regression	P-value
Bud size	$y=0.982-0.056x_1+0.7779x_2$	$r^2=0.292$*	p=0.042
Flower size	$y=7.265-0.366x_1+0.057x_2$	$r^2=0.009$ns	p=0.236
Number of petals	$y=-1.216+0.540x_1+0.662x_2$	$r^2=0.665$**	p=0.000
Stem length	$y=25.755+0.004x_1+0.650x_2$	$r^2=0.751$**	p=0.000
No. of strong canes	$y=6.106-0.115x_1+0.659x_2$	$r^2=0.222$**	p=0.000
No. of flower/plants	$y=12.391+0.096x_1+0.001x_2$	$r^2=0.007$ns	p=0.789
Bud union size	$y=0.222+0.498x_1+0.430x_2$	$r^2=0.646$**	p=0.000

For interpretation, the result showed that first budded plants developed their traits better than original plants in terms of productivity characteristics i.e. number of flower and stem length, while second budded plants developed their traits on quality i.e. flower size, number of petals and number of strong canes . Uniformity of yield and quality could be also selected on this stage.

It could be concluded that the evaluation of yield trial should be done for 2 years.

Table 4.43 Coefficients of correlation between the characteristics of 74 selected offspring, on their first and second budded plants.

Characteristics		1			2			3			4			5			6			7		
		O	FB	SB	O	FB	SB	O	FB	SB	O	FB	SB	O	FB	SB	O	FB	SB	O	FB	SB
1.Bud Size	O	1.0																				
	FB	0.3*	1.0																			
	SB	0.1	0.3*	1.0																		
2. Flower size	O	0.1	-0.1	0.0	1.0																	
	FB	0.0	0.2	-0.1	0.5**	1.0																
	SB	-0.2	0.1	0.7**	0.2	0.1	1.0															
3.Number of petals	O	0.3**	0.3*	0.2	0.2*	0.2	0.1	1.0														
	FB	0.2*	0.4**	0.2	0.3*	0.2	0.0	0.8**	1.0													
	SB	0.3*	0.3**	0.4**	0.2	0.1	0.2*	0.8**	0.8**	1.0												
4. Stem length	O	-0.1	-0.2*	-0.0	-0.1	-0.1	0.1	-0.1	-0.2*	-0.1	1.0											
	FB	0.1	0.2*	0.0	-0.3*	-0.0	-0.0	-0.1	-0.1	-0.1	0.1	1.0										
	SB	0.0	0.2	0.1	-0.3*	-0.1	0.1	-0.1	-0.1	-0.0	0.1	0.9**	1.0									
5.No. of strong canes	O	-0.1	0.2	0.2	0.3*	0.2	0.1	0.3*	0.3*	0.3*	-0.1	-0.2	-0.1	1.0								
	FB	-0.2	0.2	0.2	0.3*	0.3*	0.1	0.1	0.2	0.1	-0.0	-0.2	-0.1	0.6**	1.0							
	SB	-0.0	0.1	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.3*	0.5**	1.0						
6.No. of flowers	O	-0.1	0.2	0.1	0.2	0.2	0.0	0.2	0.1	0.1	-0.1	-0.0	-0.0	0.3*	0.5**	0.7**	1.0					
	FB	0.1	0.2*	0.2*	0.0	0.0	0.1	0.0	0.0	0.1	-0.0	0.1	0.1	0.1	0.4**	0.3**	0.6**	1.0				
	SB	0.1	0.2*	0.0	-0.2	-0.0	-0.0	0.0	0.0	0.0	-0.2	-0.0	0.0	0.1	0.1	0.3*	0.1	0.1	1.0			
7.Bud union size	O	0.0	0.0	0.1	-0.0	-0.0	0.2	-0.2	-0.2	-0.2	0.2	0.3*	0.3*	0.1	0.1	0.1	0.1	0.2	-0.0	1.0		
	FB	-0.0	0.1	0.2	0.1	0.2	0.1	-0.1	-0.0	0.0	0.1	0.1	0.1	0.1	0.4**	-0.0	0.0	0.2	-0.2	0.5**	1.0	
	SB	-0.1	0.0	0.2	0.1	0.1	0.2*	-0.1	-0.2	-0.1	0.2	0.3*	0.2	0.1	0.3*	0.1	0.1	0.3**	-0.1	0.7**	0.7**	1.0

During this stage bent peduncles were found, supposedly caused by poor transfer of water from peduncle to flower. This led to kinking of the weak wall of the trachieds, causing loss of turgidity especially during the hot months. Peduncle region's response to water stress was related to differences in the xylem conducting system. The vascular development of peduncle region was weaker and shorter than the stem, representing the sensitive part to water stress of the xylem vessel system of cut roses. Bent neck was found both during planting stage (Figure 4.26) and also after harvesting.

Figure 4.26 Bent peduncles of roses A) 05-466 B)05-183

In order to investigate into the cause of bent peduncle, free hand sectioning of the mid-region of peduncle and staining with saffanin-O was carried out. The sample was observed under the microscope. It was found that in the weak peduncle, the procambium tissue surrounded the parenchyma as in a monocotyledon plants while in the strong peduncle, the primary phloem, the vascular cambium and the primary xylem surrounded the pith regions (Figure 4.27)

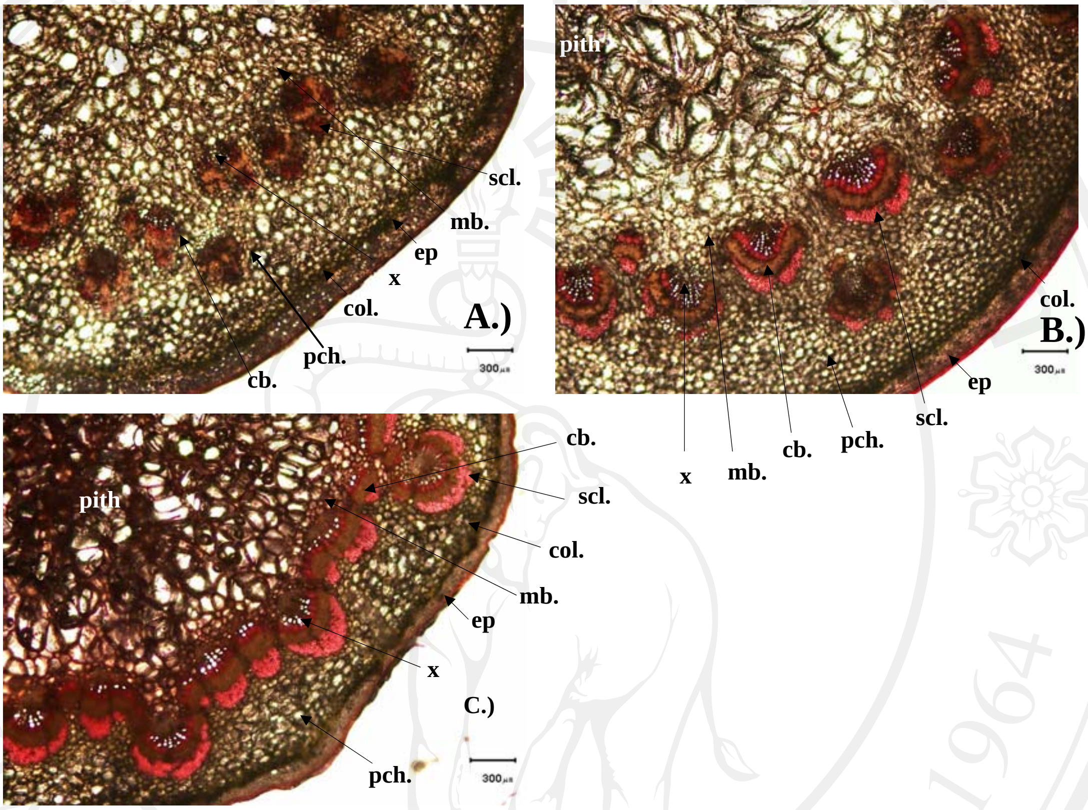


Figure 4.27 Transverse section showing general features of the xylem of mid-region of peduncle. A.) weak peduncle B.) semi-vigorous peduncle C.) vigorous peduncle Bar = 300 µm. Light micrograph of cross section shows: epidermis (ep.), cortex, collenchyma (col.), chlorophyllous parenchyma (pch.), sclerenchyma (scl.), phloem, cambium (cb.), xylem (x), medullary rays (mb.) and pith structure.

The selection results were presented in Table 4.44 and Figure 4.28 where 17 out of 34 were selected.

Table 4.44 Selected plants, their yield and quality

Selection	Grading	Productivity	Speed of production	Problem on field				Total	Accepted score	Selected
	strong canes	flowers/ plant	Flush	Peduncle weakness	Petal injury	Flower opening	Split center			
04-005	3	2	4	3	4	3	4	23	22	Y
04-007	3	2	4	3	2	1	2	17	22	N
04-010	4	3	2	3	1	3	2	18	22	N
04-027	5	4	4	2	3	3	4	25	22	Y
04-116	5	5	3	3	2	3	4	25	22	Y
04-129	4	4	3	4	2	3	4	24	22	Y
04-130	5	4	4	3	2	3	4	25	22	Y
04-131	4	3	3	3	2	3	2	20	22	N
04-161	4	3	3	4	3	3	4	24	22	Y
04-171	5	5	3	3	2	2	4	24	22	Y
04-180	4	3	3	3	2	2	3	20	22	N
04-185	3	2	4	3	2	1	3	18	22	N
04-283	5	4	4	4	2	3	4	26	22	Y
04-297	4	3	3	4	2	4	3	23	22	Y
04-298	4	3	4	3	2	3	4	23	22	Y
04-301	5	4	3	3	3	3	4	25	22	Y
04-310	4	4	2	3	4	3	4	24	22	Y
04-318	5	5	5	3	2	3	4	27	22	Y
04-329	5	4	4	4	2	4	4	27	22	Y
04-330	5	4	4	2	2	3	4	24	22	Y
04-351	4	2	4	3	2	3	2	20	22	N
04-401	4	3	4	2	1	1	4	19	22	N
05-049	4	3	3	3	3	3	4	23	22	Y
05-053	4	3	4	2	2	3	2	20	22	N
05-055	5	4	4	3	2	3	4	25	22	Y
05-060	3	2	4	1	2	3	4	19	22	N
05-093	3	2	2	3	2	1	2	15	22	N
05-184	5	4	4	2	1	2	2	20	22	N
05-189	5	4	4	2	1	2	2	20	22	N
05-229	4	2	3	1	1	3	4	18	22	N
05-293	5	4	2	3	1	1	4	20	22	N
05-299	4	3	3	1	2	1	4	18	22	N
05-325	5	4	4	1	2	2	2	20	22	N
05-359	4	3	2	3	1	3	4	20	22	N
CK	4	3	3	4	4	2	4	24	22	
Av.	4	3	3	3	2	3	3	22		

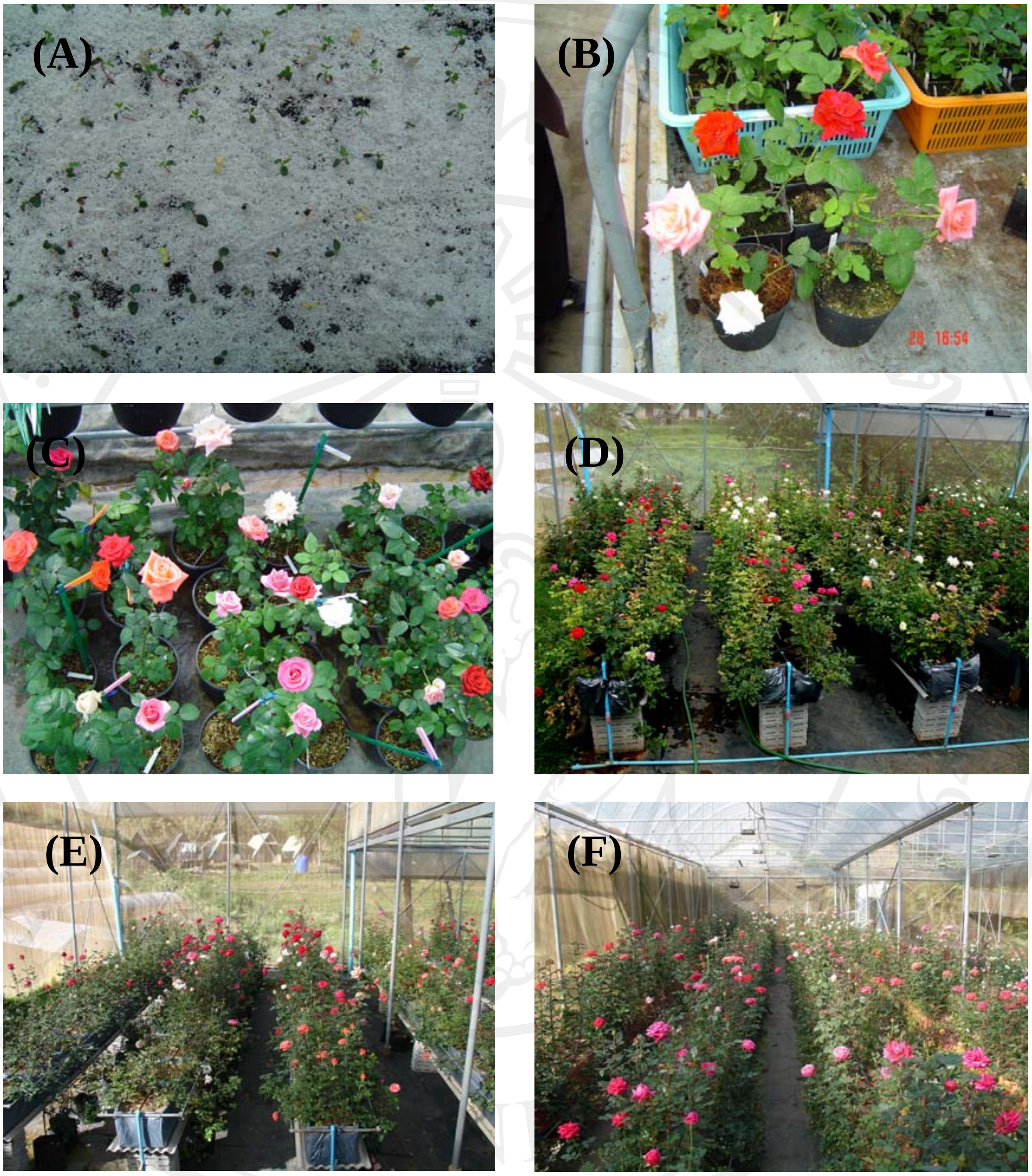


Figure 4.28 Selection stages

(A) Seedling stage
(B) Small plant size stage
(C) Medium plant size stage
(D) Large plant size stage
(E) First budding stage
(F) Second budding stage

4.3.7 Grouping of colours

17 selected numbers were grouped into 5 colours, 1.) creamy white, 2.) bicolour, 3.) apricot, 4.) pink, 5.) red (Table 4.45 and Figure 4.29). and were subsequently tested in the production trial plot using red and pink colours as representatives.

Table 4.45 Grouping of colours for yield trial

No.	Code	Visible colour	ARS code	Colour group test
1	04-027	creamy pale pink	O159C	creamy white
2	05-055	white with cherry edges	W155A/R38D	creamy white
3	04-005	vermilion orange/white	R46C/W155B	bicolour
4	04-130	coral pink	R41C	apricot
5	05-049	salmon pink	R38C	apricot
6	04-329	crimson pink	RN57A	pink
7	04-129	rose pink	R58D	pink
8	04-161	lilac pink	R56A	pink
9	04-116	cerise pink	RPN57B	pink
10	04-297	cardinal Red	R53B	pink
11	04-171	2 tone pink (candy pink/pale pink)	RPN57D/RPN57C	pink
12	04-283	cardinal red	R53D	red
13	04-318	currant red	R45B	red
14	04-298	cardinal red	R53D	red
15	04-301	turkey red	R53C	red
16	04-310	dark currant red velvet	R46A	red
17	04-330	deep pink in crimson red	RPN57A/RN57A	red

Creamy White

04-027

05-055

Apricot

04-130

05-049

Red

04-310

04-318

Pink

04-116

04-161

Bicolour

04-005

Figure 4.29 Five colour groups of 17 selected numbers

4.4 Inheritance of parents

4.4.1 Cytological study

Selected numbers of red and pink colours as representatives were studied for chromosome number. The result showed that the comparison of the chromosome number between 6 selected red roses, 6 selected pink roses and their parents were similar with 2n=28. It indicated that crossing with the same chromosome number parent had the same number of chromosome and not different in offspring of different colours as displayed in Table 4.46 and Figure 4.48.

Table 4.46 Chromosome number of 12 selected offspring and their parents

Selected number	Crosses	number of cells with the chromosome number of										Mode
		1	2	3	4	5	6	7	8	9	10	
Selected red rose												
04-283	SPxDL	26	28	29	28	28	26	29	27	28	29	28
04-298	SPxDL	25	26	28	26	27	27	26	28	28	28	28
04-301	SPxDL	28	28	27	26	27	29	31	26	26	28	28
04-310	BMxDL	27	28	26	27	28	30	26	28	28	27	28
04-318	SPxDL	27	28	28	29	27	30	28	28	26	27	28
04-330	DPMxDL	31	30	28	28	28	29	30	29	28	28	28
Selected pink rose												
04-116	TNKxDL	28	26	26	28	28	27	26	24	25	27	28
04-129	AZxDL	26	28	28	26	25	28	26	27	29	28	28
04-161	RVxDL	28	28	30	28	28	28	26	26	28	28	28
04-171	SPxDL	26	31	28	22	24	27	26	28	28	28	28
04-297	TNKxDL	29	28	28	26	29	28	31	27	29	28	28
04-329	DPMxDL	25	29	27	28	28	26	26	28	28	29	28
Parent												
AZ		30	29	28	27	27	30	28	28	27	28	28
BM		28	28	28	27	27	26	27	28	27	28	28
DL		28	28	28	26	26	27	28	29	27	28	28
DPM		28	27	27	28	28	27	28	27	25	26	28
RV		28	30	27	29	31	28	28	29	29	32	28
SP		27	29	26	26	27	28	28	29	28	28	28
TNK		26	28	28	28	28	28	3	26	27	26	28

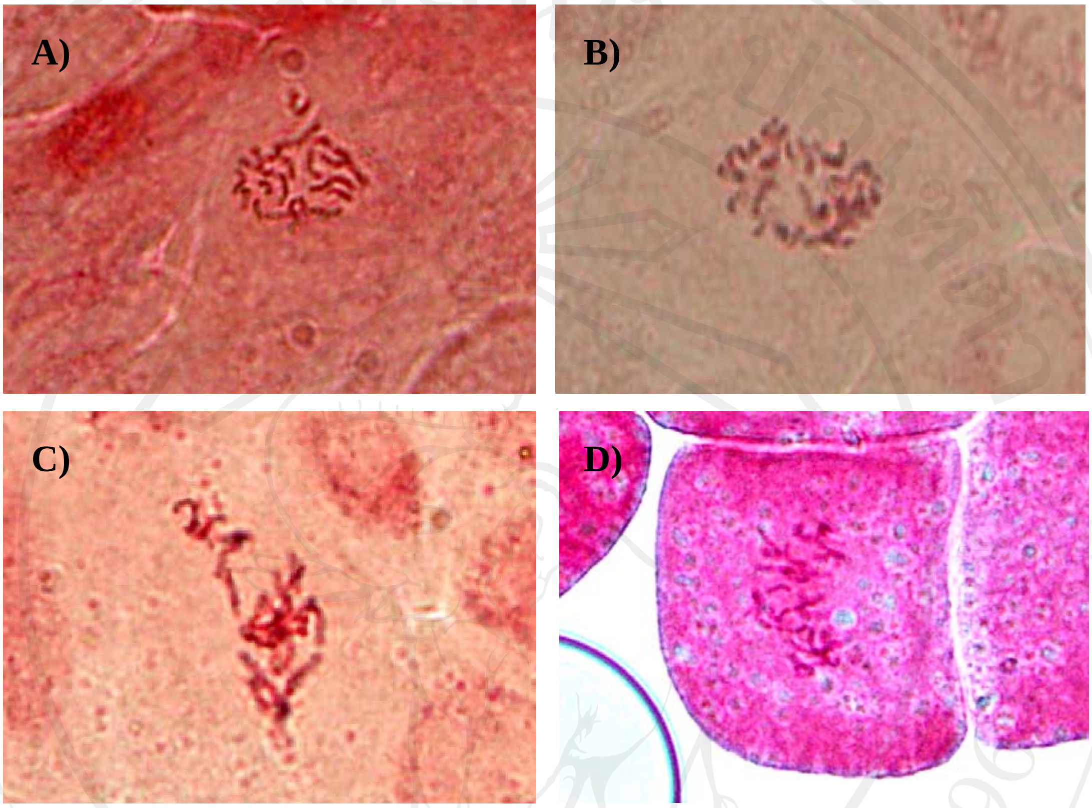


Figure 4.30 Appearance of rose chromosomes

A) Tineke B) Ravel C) 04-301 D) 04-330

4.4.2 DNA fingerprint

Twenty-eight primers were used in RAPD fingerprinting for hybrid identification. The results showed that it could indicate the genetic relationships in parental rose, but could not identify hybrid in rose hybrid. Molecular marker was a reliable and rapid way to identify hybrids in many plants. RAPD marker was popular for its low cost and technical simplicity, but its extensive use was limited by its poor reproducibility when amplification conditions changed. In this study, Figure 4.49A and 4.49B showed comparison within parent ‘SP’ and ‘DL’. There were unclear bands of parents by using primer OPAU-03, while other primer gave a clear picture. The bands of parent and progeny ‘SPxDL’ and ‘BMxDL’ were also shown clearly by using primer OPAU-08, while the bands of same lane were different by using OPAH-03. It indicated that RAPD-PCR could not identify hybrid in rose hybrid. For further studies, combination with molecular markers such as: RAPD, PCR-RFLP, AFLP, ISSR or DNA sequencing should be used.

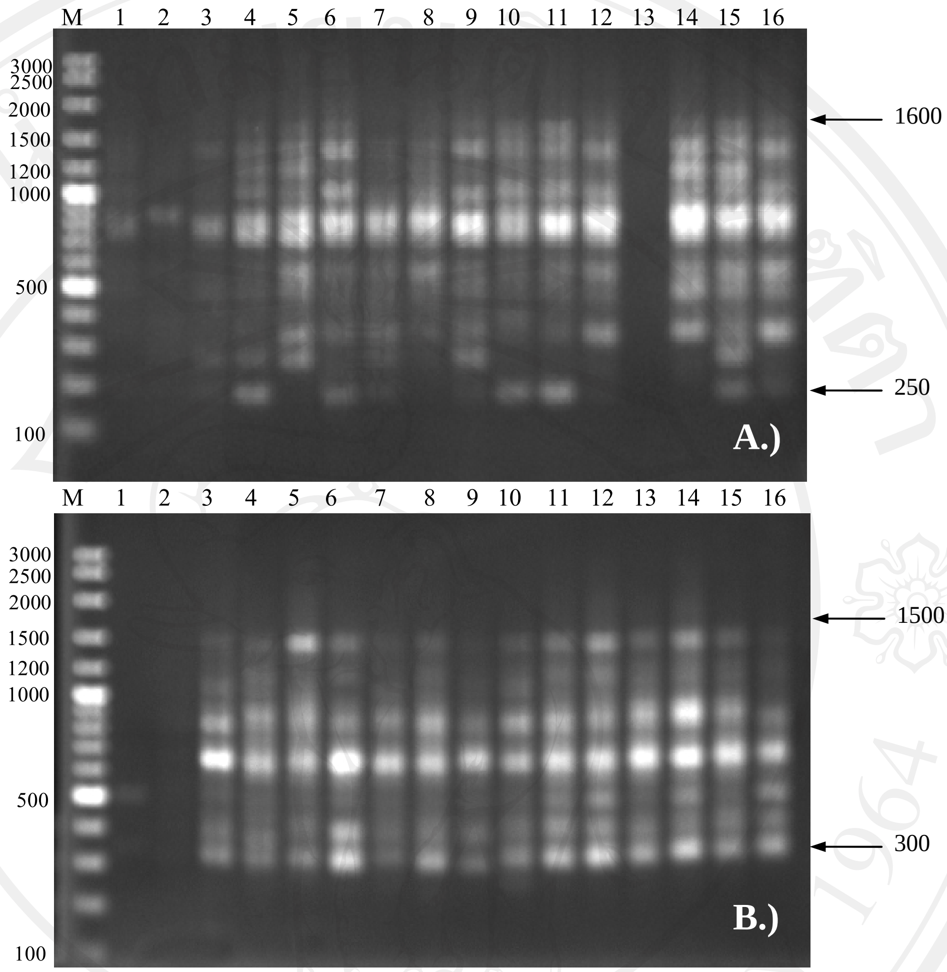


Figure 4.31 HAT-RAPD profile of 16 varieties using different primers showed different number of bands appearance between parents (A) OPAU 08 primer amplified 111 band, range 250-1600 bp (B) OPAH 03 primer amplified 90 band, range 300-1,500 bp. M represents 100 bp DNA ladder. The rose parent were 1=SP, 2=DL, 3=04-283, 4=04-298, 5=04-301, 6=04-318, 7=BM, 8=04-171, 9=04-310, 10=04-330, 11=04-329, 12=04-129, 13=04-116, 14=04-297, 15=04-161, 16=DPM.

4.4.3 Heritability

The heritabilities of plants used as a female were assessesed from 89 plants obtained by crossing 6 females to same male and the heritabilities of plants used as a male were evaluated from 58 plants obtained by crossing same female to 6 males. Genetic inheritance from the total of 139 plants from 11 selected families (each family had >5 selected plants) were taken and compared with their parent varieties

4.4.3.1 Female effects

a.) Analysis of Variance In Table 4.47, contrast comparison of combination between same male and different female parents were analyzed. The results showed that high significance was found on the characteristics of size of flower, peduncle length and number of petals. 'Tineke' gave the best progeny with larger size of flower, peduncle length and number of petals. 'Pink Noblesse' gave the progeny with small bud size and shortest peduncle length. 'Saphir' and 'Azure Sea' gave a little number of petals to the progeny. All female parents gave non-significant flower diameter, peduncle/flower ratio and stem length.

Table 4.47 Mean of traits for 6 crosses from same male and different females.

Female x DL	No. of plants	Size of flower (cm.)	Flower diameter (cm.)	Peduncle length (cm.)	Peduncle/ flower ratio	Number of petals	Stem length (cm.)
AZ	10	2.1±0.3b	7.8±1.0	8.6±1.6b	2.8±0.6	28.2±5.3c	87.2±14.9
DPM	10	2.2±0.3a	7.7±1.2	8.8±1.6b	2.8±0.5	35.6±9.7b	82.3±14.2
PNB	15	2.0±0.2c	6.8±0.8	7.7±1.5c	2.6±0.5	37.1±9.7b	79.1±10.1
SP	39	2.0±0.2bc	7.3±1.0	8.4±1.4b	2.7±0.5	29.9±8.8c	84.0±13.8
TNK	8	2.3±0.3a	6.5±1.3	10.3±1.4a	3.1±0.2	43.2±13.1a	87.0±10.8
OSN	7	2.3±0.3a	7.2±0.8	7.9±1.3c	2.3±0.4	28.9±9.2c	89.6±20.2
LSD		0.1	0.3	0.4	0.2	2.8	4.1
Female		**	ns.	**	ns	**	ns
CV (%)		10.7	14.1	16.8	17.9	28.3	16.4

*, ** significant at the 0.05 and 0.01 probability levels, respectively

b.) Regression of offspring on parent Female heritability having effects on several traits were presented in Table 4.48 i.e. number of petals, flower diameters, peduncle length, peduncle/flower ratio and flower bud size, respectively. The estimates of heritability indicated not only the inheritance ability, but also the distributions of offspring in each family, as presented in Figure 4.50.

Table 4.48 Female heritability, computed from parent-offspring regression

Trait	Parent-offspring regression	
	Estimate	std error
Size of flower	0.12	0.133
Flower diameter	0.19	0.157
Peduncle length	0.19	0.091
Peduncle /flower ratio	0.17	0.125
Number of petals	0.86	0.287
Stem length	0.10	0.126

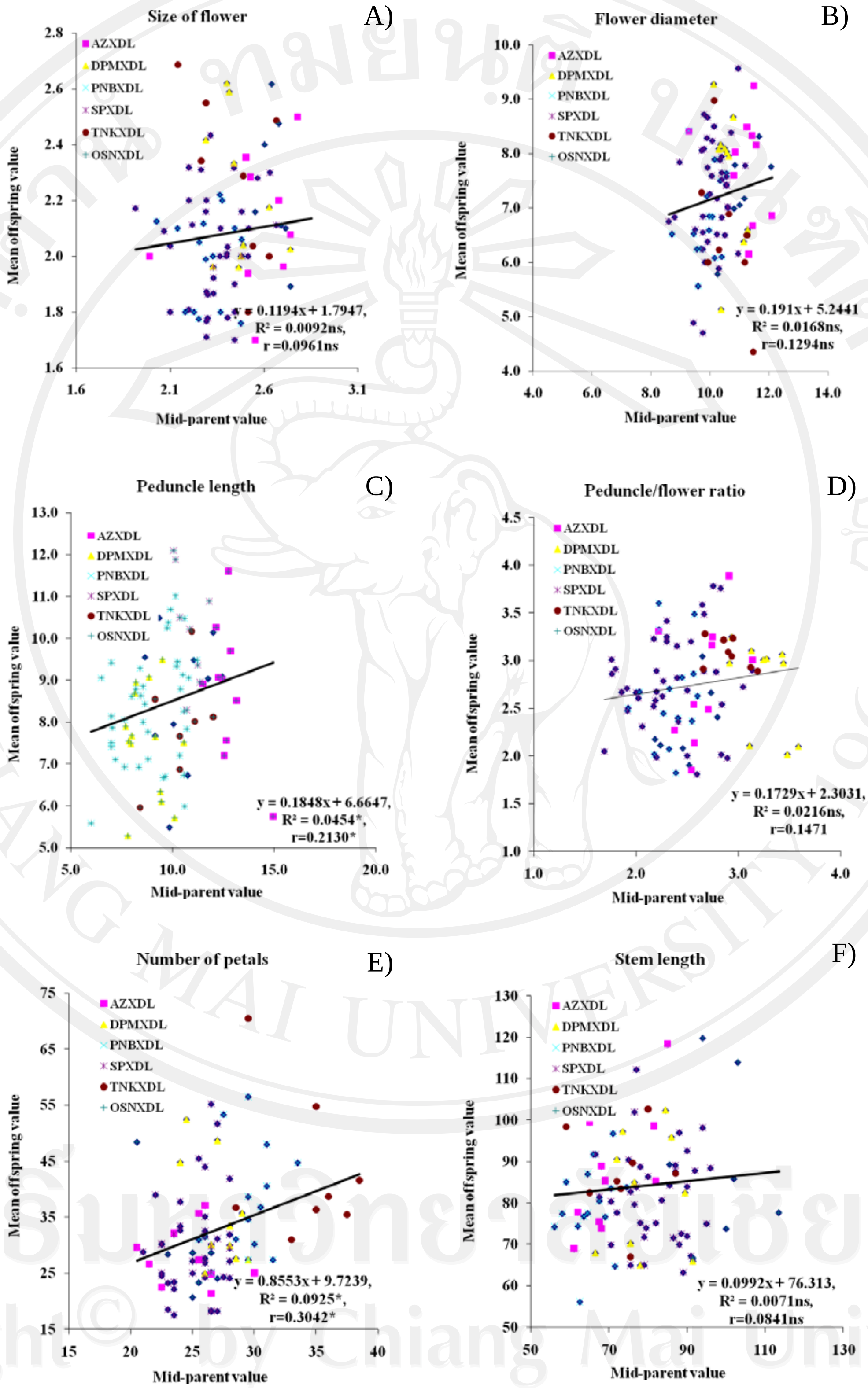


Figure 4.32 Scatter plots showing the relation between the mean offspring value and the mid-parent value for (fixed male) A.) size of flower, B.) flower diameter, C.) peduncle length, D.) peduncle/flower ratio (E.) number of petals (F.) stem length

4.4.3.2 Male effects

a.) Analysis of Variance Combination of same female and different male was significant with flower and stem length (Table 4.49). 'First red', 'Kardinal' and 'Osiana' gave progeny with large flower size. 'Osiana' and 'Vivaldi' gave progeny with long stem length.

Table 4.49 Mean of traits for 6 crosses from same female and different males

TNK x male	No. of plants	Size of flower (cm.)	Flower diameter (cm.)	Peduncle length (cm.)	Peduncle/ Bud size ratio	Number of petals	Stem length (cm.)
DL	8	2.3±0.2	6.5±1.3b	10.4±1.5	3.1±0.2	43.2±13.1	87.0±10.8ab
EMB	6	2.1±0.5	7.3±0.9ab	9.2±1.4	3.0±0.8	49.6±23.3	73.5±9.6b
FR	12	2.2±0.2	7.8±0.8a	9.8±2.3	3.1±0.7	41.6±16.2	74.8±8.4b
KDN	5	2.3±0.1	8.2±1.2a	8.6±1.5	2.7±0.7	36.9±4.2	72.5±7.5b
OSN	15	2.2±0.3	8.0±1.0a	10.1±2.6	2.8±0.6	37.8±15.5	91.3±17.4a
VVD	12	2.2±0.3	7.6±1.2ab	8.8±2.7	2.7±0.7	38.2±16.3	90.5±16.3a
LSD		0.3	1.3	2.6	0.7	18.4	15.6
Male		ns	*	ns	ns	ns	**
CV (%)		12.9	14.2	23.6	22.0	39.2	16.1

*, ** significant at the 0.05 and 0.01 probability levels, respectively

b.) Regression of offspring on parent Male heritability effects were present on peduncle length, stem length, flower diameter, peduncle/flower ratio, size of flower and number of petals, as shown in Table 4.51 and Figure 4.51.

Table 4.50 Male heritability, computed from parent-offspring regression

Trait	Parent-offspring regression	
	Estimate	Std error
Size of flower	0.10	0.218
Flower diameter	0.39	0.203
Peduncle length	0.55	0.285
Peduncle /flower ratio	0.27	0.229
Number of petals	0.06	0.672
Stem length	0.46	0.176

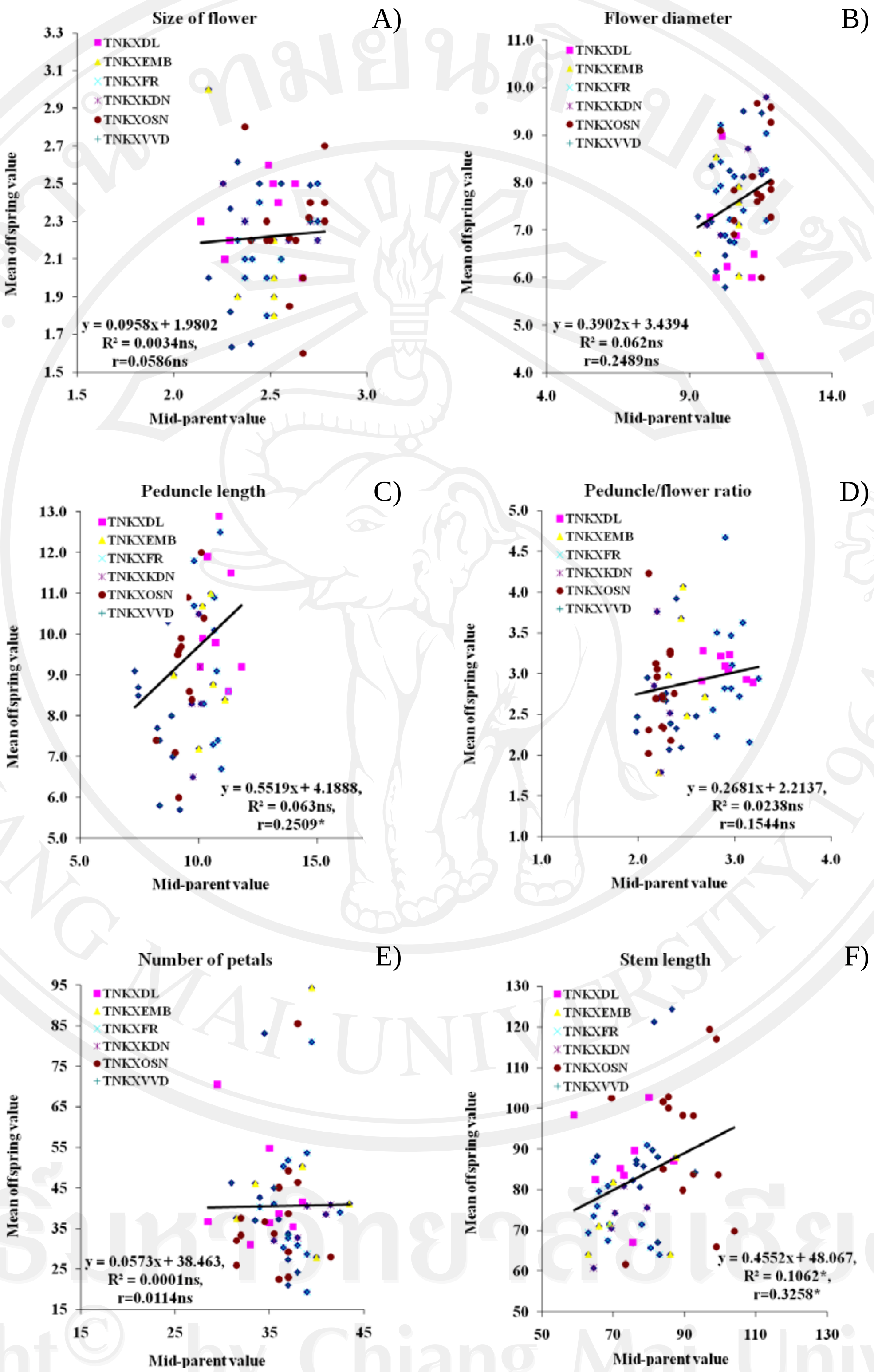


Figure 4.33 Scatter plots showing the relation between the mean offspring value and the mid-parent value (fixed female) for A) Size of flower, B) flower diameter, C) peduncle length, D) peduncle/flower ratio, E) number of petals , F) stem length

4.5 Yield trial

Red and Pink selected numbers were evaluated under greenhouse condition. Each colour was compared with the standard check (Figure 4.34).

Figure 4.34 Greenhouse yield trial

A) Selected red rose B) Selected pink rose

4.5.1 Red flower colour

a.) Yields Flower number for 3 seasons for two years of 6 red selected number and standard check were presented in Table 4.51. Most of the red offspring had a significantly higher yield than the standard check**.** Seasonal effect on harvesting had significant effect on yields. Second year yield was better than first year, both in flower number and quality. The number of stems during summer and rainy seasons was higher than winter seasons. Overall, the varieties 04-318 and 04-330 were the best two. In average '04-318' produced the highest yield. (Table 4.51)

Table 4.51 Yield (stems/m^2) of 6 red offspring and standard check varieties over 3 seasons, in the same location for 2 consecutive years.

Year	Seasons	04-283	04-298	04-301	04-310	04-318	04-330	R-CK	Sum	Av.
1	Rainy	75.6jk	77.8h-j	83.4gh	67.4m-o	84.7g	87.7e-g	53.9qr	530.6	75.8d
	Winter	62.9op	69.1l-n	66.5m-o	46.9s	64.5n-p	64.3n-p	37.4t	411.6	58.8f
	Summer	95.6d	124.2a	109.3bc	82.5g-i	128.7a	123.4a	73.8j-l	737.5	105.4b
	Sum	234.1	271.1	259.2	196.8	277.9	275.5	165.0	1679.7	240.0
2	Rainy	86.6fg	87.8e-g	93.0de	78.3h-j	92.0d-f	105.0c	59.1pq	601.7	86.0c
	Winter	70.7k-m	78.1h-j	77.9h-j	51.0rs	86.3 fg	76.6ij	45.5s	486.1	69.4e
	Summer	95.2d	128.8a	111.8b	91.3d-f	126.3a	123.7a	76.9ij	754.0	107.7a
	Sum	252.5	294.7	282.5	220.7	304.6	305.3	181.5	1841.8	263.1
Av.	Year 1	78.0	90.4	86.4	65.6	92.6	91.8	55.0	559.9	80.0b
	Year 2	84.2	98.2	94.2	73.6	101.5	101.8	60.5	613.9	87.7a
	Av. Year	81.1d	94.3b	90.3c	69.6e	97.1a	96.8a	57.8f	586.9	83.8
	Difference	6.1	7.9	7.8	8.0	8.9	10.0	5.5	54.1	7.7

b.) Grading The result showed that in summer, plants produced the highest yields, but with B and C grade. On the contrary, in winter yields were low, but with better quality, (Extra and A grade). The high number of unmarketable flowering shoots during summer could be attributed to high temperatures that increased the number of flowering shoots per plant but reduced stem length and hence, stem quality. In '04-318' and '04-330', although the total number of flowering shoots was higher than other varieties, the number of low grades (C and U) was higher also. On the other hand, with 'R-CK', the number and the proportion of high-grade flowers (grades Extra and A) were the highest, but the total number of flowering shoots was the lowest. In the second year, plants (Figure 4.35) gave maximum grade quality (B grade) better than the first year (C grade).

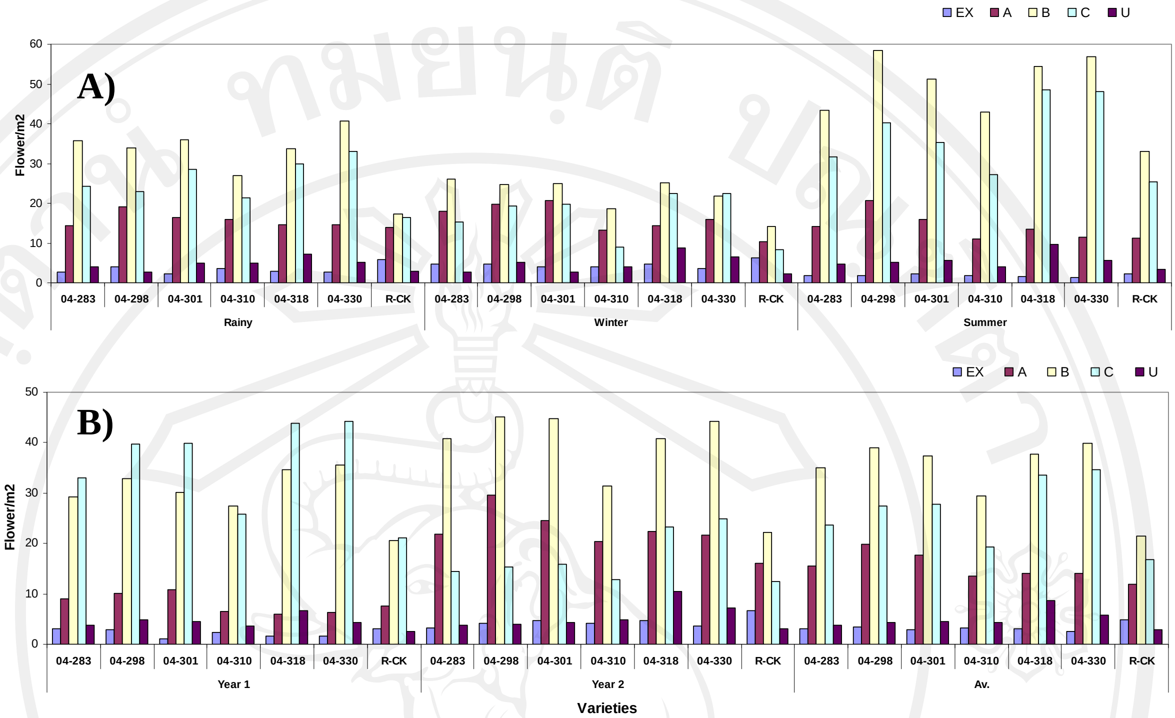


Figure 4.35 Graded yield of 6 red offspring and standard check varieties over 3 seasons, in the same location for 2 consecutive years

A) Season B) Year

c.) Flush Second year had shorter flush than first year. The comparison of flush in summer, rainy and winter, appeared in Table 4.52. ‘04-318’ had the shortest period, while ‘04-310’ produced the longest period.

Table 4.52 Flush of 6 selected red roses and standard check over 3 seasons, in the same location for 2 consecutive years.

Year	Seasons	04-283	04-298	04-301	04-310	04-318	04-330	R-CK	Sum	Av.
1	Rainy	60.0h-j	56.7jk	58.3ij	68.3cd	51.0l-o	52.0l-n	60.7f-i	407.0	58.1c
	Winter	65.7de	65.3de	66.3c-e	81.7a	60.7f-i	67.0c-e	73.7b	480.4	68.6a
	Summer	51.0l-o	47.7o-r	49.3m-p	59.0ij	43.3s-u	47.7o-r	54.0kl	352.0	50.3e
	Sum	176.7	169.7	174.0	209.0	155.0	166.7	188.3	1239.4	177.0
2	Rainy	54.0kl	52.7lm	52.7lm	64.0e-g	47.0p-s	49.7m-p	56.7jk	376.8	53.8d
	Winter	60.3g-j	61.3f-i	63.3e-h	77.0b	58.3ij	64.3ef	69.7c	454.2	64.9b
	Summer	42.0tu	43.3tu	45.3g-t	53.0k-m	41.3u	44.0r-u	48.70n-q	317.6	45.4f
	Sum	156.3	157.3	161.3	194.0	146.7	158.0	175.0	1148.6	164.1
Av.	Year 1	58.9c	56.6de	58.0cd	69.7a	51.7g	55.6ef	62.8b	413.3	59.0a
	Year 2	52.1g	52.4g	53.8fg	64.7b	48.9h	52.7g	58.3cd	382.9	54.7b
	Av. Year	55.5	54.5	55.9	67.2	50.3	54.1	60.6	398.1	56.9
	Difference	-6.8	-4.1	-4.2	-5.0	-2.8	-2.9	-4.4	-30.2	-4.3

d.) Harvesting stage and vase life The result showed that vase life depended on cut-stage and season. The correct harvesting stage gave the good vase life in every season. Vase life was shown in seasonal order i.e. winter, rainy and summer, respectively. Winter season gave longer vase life than other seasons. The best harvesting-stage for all varieties was second stage. The best average vase life was selection number ‘04-310’ and the shortest vase life was ‘04-318’. Although ‘04-310’ was sensitive to bent neck, because of its long stem lengths which was possibly related to water deficiency stress during water transportation inside flower stem, it had longer vase life than ‘R-CK’. Figure 4.54 showed most varieties to be susceptible to *botrytis* disease, but of different levels.

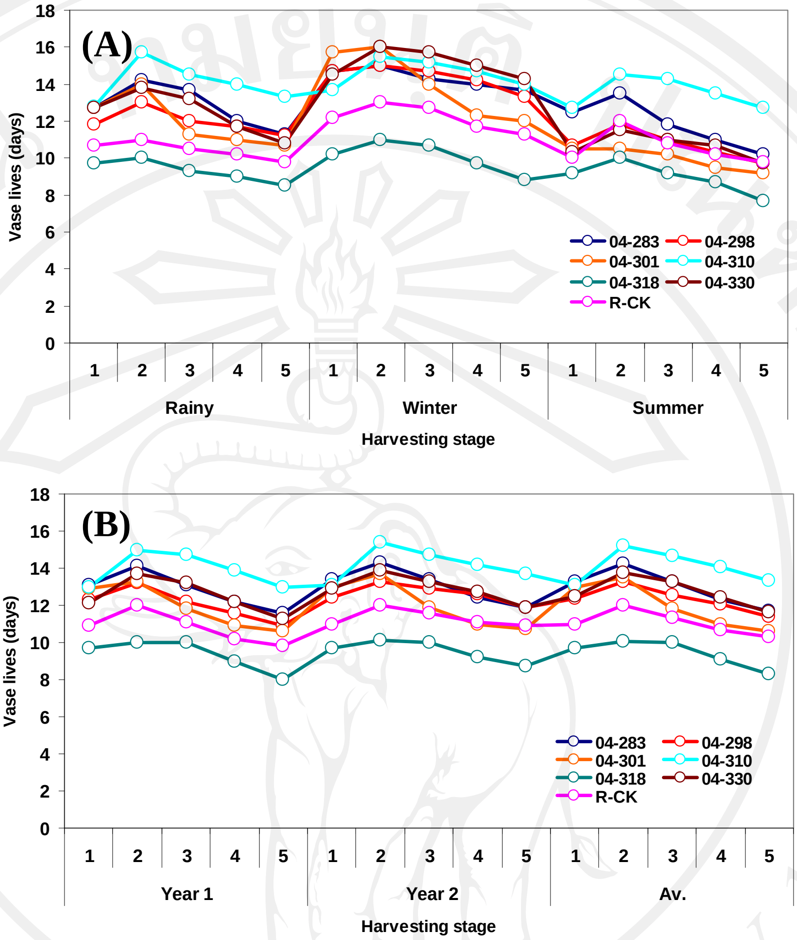


Figure 4.36 Vase life in various harvesting stage of 6 red offspring and standard check varieties tested over 3 seasons, in the same location for 2 consecutive years.

A) Season B) Year

In ‘04-318’ and ‘R-CK’, change in petals colour or fading was not found, but ‘R-CK’ opened very rapidly 2 days after test. Flower buds at first harvesting stage of most varieties could not open in vase, indicating that flowers harvested at this stage had not sufficient photosynthate or food to open (Figure 4.37).

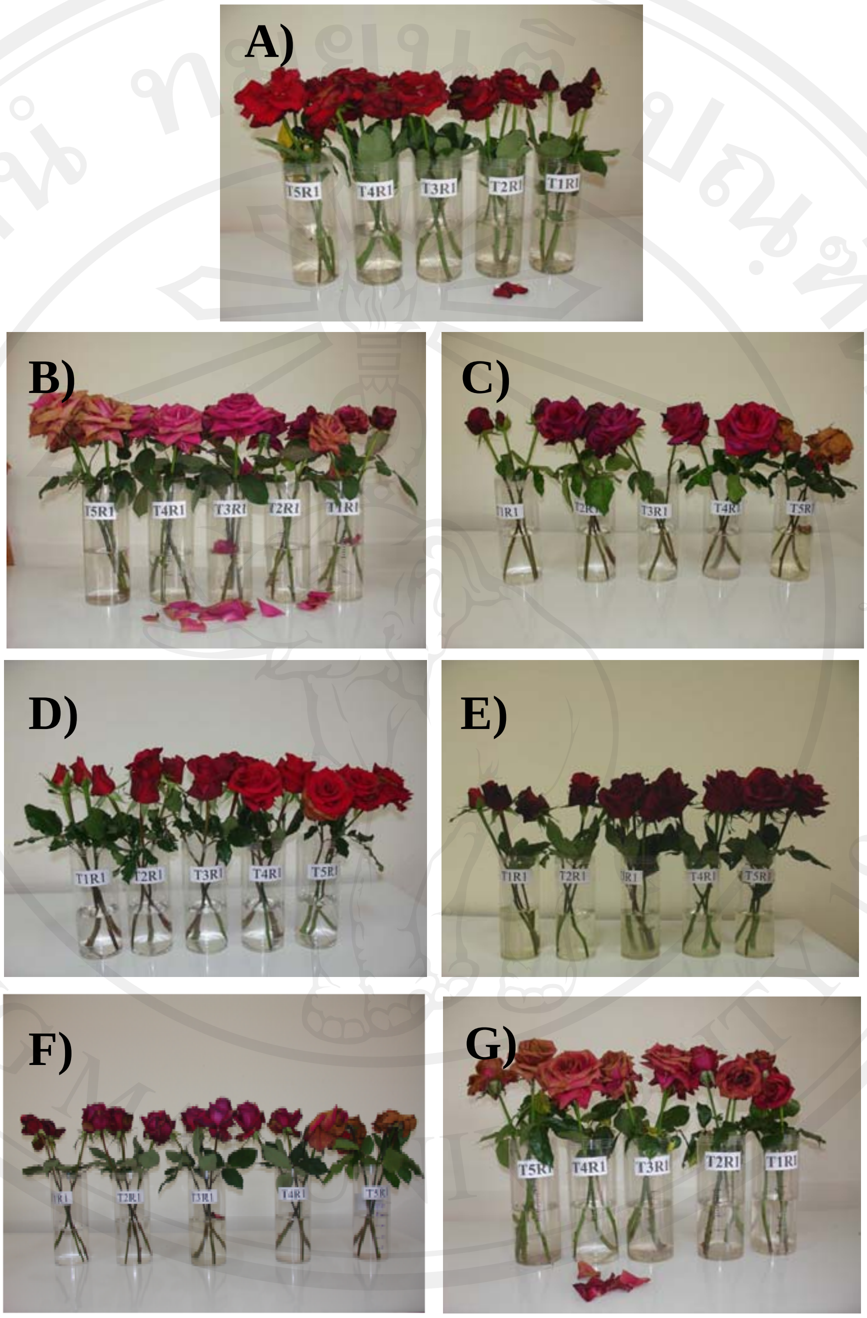


Figure 4.37 Vase life evaluation at various harvesting stages :

(T1=unripe, T2= minimum open, T3=medium open,

T4=maximum open, T5=fully open), 10 days after test

A) R-CK B) 04-283 C) 04-301 D) 04-298

E) 04-310 F)04-318 G) 04-330

Collections of all data in each selection numbers for individual selection were evaluated and presented in Table 4.53.

Table 4.53 Overall plant performance of 6 selected numbers and standard check

Characteristics	Details	Total score	Accept. score	04-283	04-298	04-301	04-310	04-318	04-330	R-CK
Plant Characters	bush	5	4.7	5	3	5	5	5	5	5
(25 points)	stem length	5	4.6	5	5	4	5	4	4	5
	bud union	5	4.3	4	3	4	5	5	4	5
	side shoots	5	2.9	3	4	3	2	3	2	3
	thorns	5	2.9	3	3	3	3	3	2	3
	sum	25	19.3	20	18	19	20	20	17	21
Problem on Field	spiral center opening	5	4.6	2	5	5	5	5	5	5
(25 points)	flower opening	5	4.7	3	5	5	5	5	5	5
	fading flower	5	4.7	5	5	5	5	4	4	5
	bent neck(strong peduncle)	5	4.6	5	5	5	4	5	3	5
	flower shape	5	4.9	4	5	5	5	5	5	5
	sum	25	23.4	19	25	25	24	24	22	25
Flower Characters	beauty of un-open stage	5	5.0	5	5	5	5	5	5	5
(60 points)	beauty of semi-open stage	5	4.9	4	5	5	5	5	5	5
	beauty of open stage	5	4.7	3	5	5	5	5	5	5
	brightness of colour	5	5.0	5	5	5	5	5	5	5
	Cleanness of colour	5	5.0	5	5	5	5	5	5	5
	petal thickness	5	4.4	4	4	5	4	5	4	5
	petal texture	5	5.0	5	5	5	5	5	5	5
	straightness of stem	5	5.0	5	5	5	5	5	5	5
	proportion of stem and leaves	5	4.4	4	5	5	3	4	5	5
	glossiness of leaves	5	2.7	3	1	5	3	3	2	2
	size of flower	5	4.3	4	4	4	5	4	4	5
	number of petals	5	3.1	3	3	3	3	3	4	3
	sum	60	53.6	50	52	57	53	54	54	55
Productivity Trends	uniformity of sprouting	5	4.4	5	3	5	4	5	5	4
(60 points)	sprouting after bending	5	3.6	4	3	4	3	4	4	3
	sprouting after harvesting	5	4.6	5	4	5	4	5	5	4
	building the plant	5	3.9	4	2	4	4	5	5	3
	flush to flush	5	3.0	3	4	3	1	4	4	2
	levels to propagation	5	4.9	5	4	5	5	5	5	5
	levels to bending	5	4.6	5	4	5	5	4	5	4
	productivity	5	3.6	3.5	4.5	4	2.5	4.5	4.5	1.5
	>%CK	5	4.0	3.5	5	4.5	3	5	5	2
	%high/ low grade	5	2.7	3	3	3	3	2	2	3
	vase life	5	3.6	4	3	4	4	3	4	3
	transport	5	3.7	4	3	4	5	3	3	4
	sum	60	46.4	49	42.5	50.5	43.5	49.5	51.5	38.5

Four offspring with low scores were discarded. Remaining 2 offspring with good cut-rose characteristics and highest scores, '04-301' and '04-318' were selected and kept for the advanced sensory trial to compare with standard check. For this stage, 66.7% were selected and 33.3% discarded (Table 4.54).

Table 4.54 Summary of 5 major characteristic of 6 selected numbers and standard check

Characteristics	Total score	Accept. score	04-283	04-298	04-301	04-310	04-318	04-330	R-CK
Growth Habit	25.0	19.3	20.0	18.0	19.0	20.0	20.0	17.0	21.0
Problem on Field	25.0	23.4	19.0	25.0	25.0	24.0	24.0	22.0	25.0
Flower Characters	60.0	53.6	50.0	52.0	57.0	53.0	54.0	54.0	55.0
Productivity Trends	60.0	46.4	49.0	42.5	50.5	43.5	49.5	51.5	38.5
Total score (point)	170.0	142.7	138.0	137.5	151.5	140.5	147.5	144.5	139.5
Rank					1		2		
Discarded/Selected			Discarded	Discarded	Selected	Discarded	Selected	Discarded	Check

4.5.2 Pink flower colour

a.) Yields The results indicated that season and age of plants had significant effect on flower number. Grain yield production depended on seasons i.e. highest in summer, moderately high in rainy season and lowest in winter. For age of plant, second year gave better yield and quality than first year, similar to red offspring. '04-329' and '04-171' gave highest grain yield. '04-329' gave higher yields with high-grade (Extra and A grades); but '04-171'gave also higher yield with lower C and U grades. Averages of flower number of 6 selected pink roses compared with standard check were presented in Table 4.55.

Table 4.55 Yield (stems/m^2) of 6 selected pink offspring and standard check varieties over 3 seasons, in the same location for 2 consecutive years.

Year	Seasons	04-116	04-129	04-161	04-171	04-297	04-329	P-CK	Sum	Av.
1	Rainy	68.0k-o	56.3q-s	67.0l-o	74.8i-m	54.1r-s	66.3m-o	75.4i-l	462.0	66.0d
	Winter	49.9s-u	42.6u	50.3s-u	63.7n-q	44.2tu	57.6p-s	65.6n-p	374.0	53.4e
	Summer	86.5fg	92.3ef	87.2fg	96.3de	85.0f-h	123.0a	86.8fg	657.2	93.9b
	Sum Year1	204.4	191.2	204.6	234.8	183.4	246.9	227.8	1493.1	213.3
2	Rainy	70.9j-n	66.5m-o	76.9h-j	89.3e-g	71.9j-n	87.5 fg	84.6f-h	547.5	78.2c
	Winter	59.8o-r	51.7r-t	59.8o-r	81.9g-i	63.5n-q	76.3i-k	66.8l-o	459.7	65.7d
	Summer	90.7e-g	85.7fg	109.2bc	111.4b	85.0 f-h	112.7b	103.4cd	698.2	99.7a
	Sum Year2	221.4	203.8	245.9	282.5	220.5	276.4	254.8	1705.4	243.6
Av.	Year 1	68.1f	63.7fg	68.2f	78.3cd	61.1g	82.3bc	75.9de	497.7	71.1b
	Year 2	73.8de	67.9f	82.0bc	94.2a	73.5e	92.1a	84.9b	568.5	81.2a
	Av. Year	71.0d	65.8e	75.1c	86.2a	67.3e	87.2a	80.4b	533.1	76.2
	Difference	5.7	4.2	13.8	15.9	12.4	9.9	9.0	70.8	10.1

b.) Grading Figure 4.38, B and C grades gave higher yields during summer. In average, all pink offspring produced more B grades. '04-329' gave higher grades (Extra and A grade). Second year gave better grade than first year.

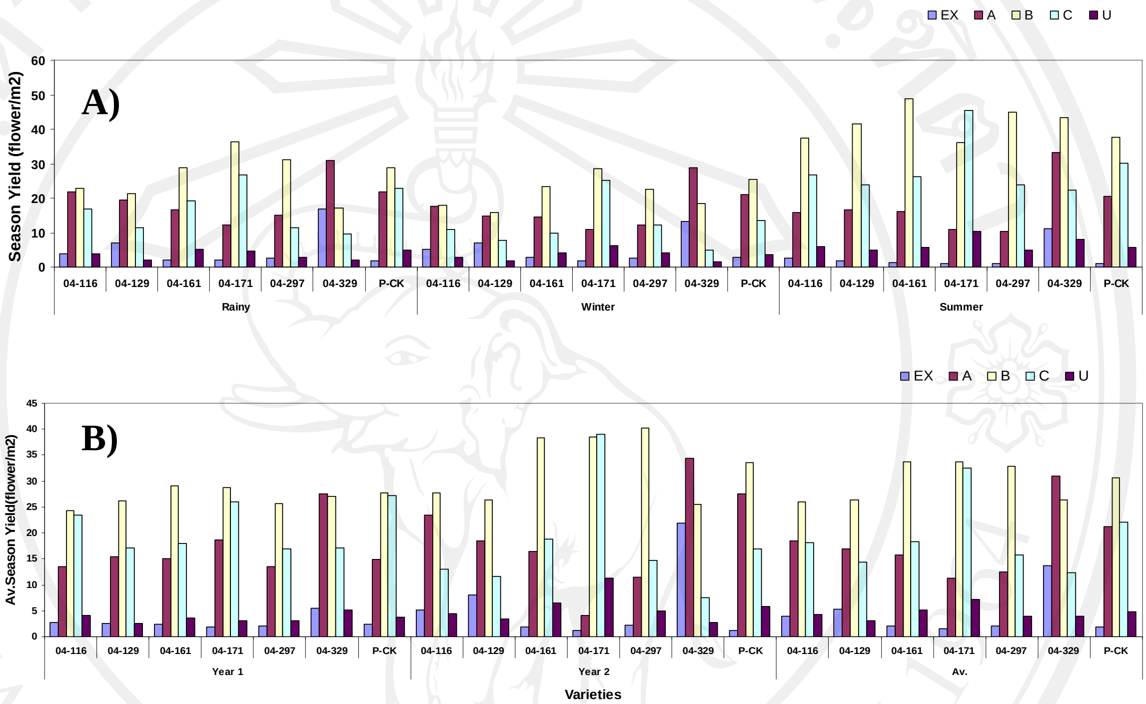


Figure 4.38 Graded yields of 6 pink offspring and standard check varieties over 3 seasons, in the same location for 2 consecutive years.

A) Season B) Year

c.) Flush Table 4.56 showed flush of pink offspring in different seasons over the 2 years. Second year had shorter flush than first year, especially with the red offspring. '04-329' had the shortest flush, while '04-310' produced the longest flush.

Table 4.56 Flushes of 6 pink offspring and standard check varieties over 3 seasons, in the same location for 2 consecutive years.

Year	Seasons	04-116	04-129	04-161	04-171	04-297	04-329	P-CK	Sum	Av.
1	Rainy	58.7	63.3	60.3	60.0	59.0	51.7	63.0	416.0	59.4c
	Winter	71.3	71.7	70.0	72.3	70.0	62.3	73.0	490.7	70.1a
	Summer	49.3	48.3	49.0	50.0	47.7	42.7	53.7	340.7	48.7e
	Sum Year1	179.3	183.3	179.3	182.3	176.7	156.7	189.7	1247.3	178.2
2	Rainy	53.0	56.0	54.3	53.7	52.3	48.0	59.0	376.3	53.8d
	Winter	66.0	66.3	65.0	65.0	64.7	55.7	70.7	453.3	64.8b
	Summer	45.3	47.3	43.0	42.7	43.3	40.0	48.7	310.3	44.3e
	Sum Year2	164.3	169.7	162.3	161.3	160.3	143.7	178.3	1140.0	162.9
Av.	Year 1	59.8	61.1	59.8	60.8	58.9	52.2	63.2	415.8	59.4a
	Year 2	54.8	56.6	54.1	53.8	53.4	47.9	59. 5	380.0	54.3b
	Av. Year	57.3c	58.8b	56.9c	57.4c	56.2c	50.1d	61.3a	397.9	56.8
	Difference	-5.0	-4.6	-5. 7	-7.0	-5.5	-4.3	-3. 8	-35.8	-5.1

d.) Harvesting stage and vase life Figure 4.39 showed that the plant's age had no significant effects on vase life of pink varieties. The average vase lives of first and second years were 12.4 and 13.0 days, respectively. The best cut-stage for all varieties in the two years was the second stage. The longest vase life variety was '04-161' for two years, while '04-329' was shortest vase life variety. Although '04-329' gave the highest yields and good quality, its number of petals presented the problem of balling (outer petals would not open) which was sometimes caused by *botrytis*.

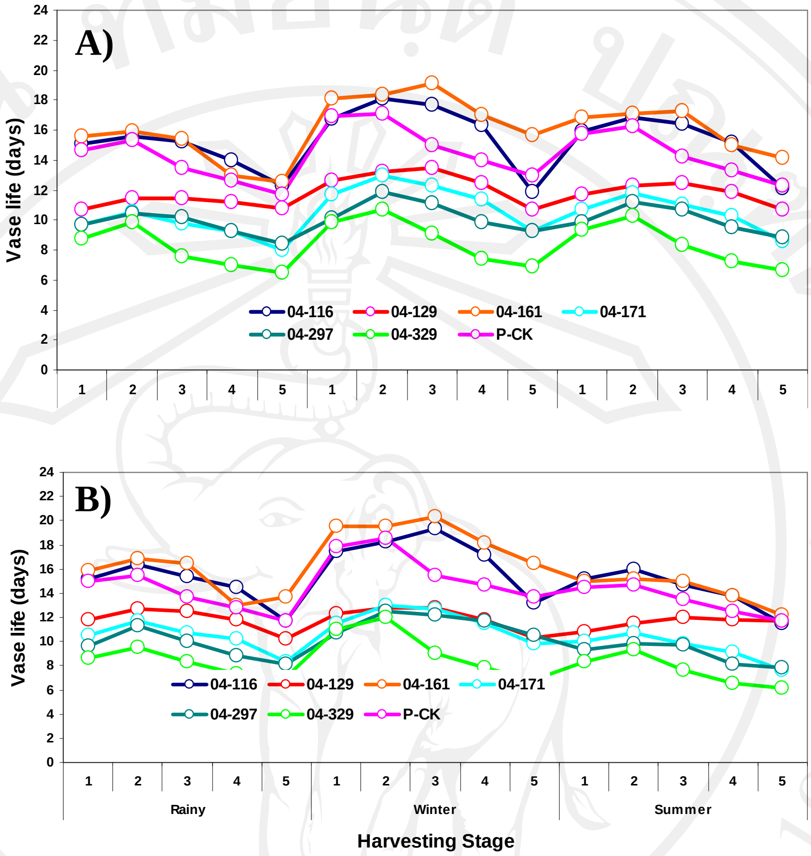


Figure 4.39 Vase life in various harvesting stages of 6 pink offspring and standard check varieties over 3 seasons, in the same location for 2 consecutive years

A) Season B) Year

Figure 4.40 Vase life evaluation at various harvesting stages : (T1=unripe, T2= minimum open, T3=medium open, T4=maximum open, T5=fully open), 10 days after test

A) P-CK   B) 04-116   C) 04-129   D)04-161

E) 04-171   F)04-297   G) 04-329

Collections of all data in each selected number were evaluated as follows Table 4.57.

Table 4.57 Overall plants performance of 6 pink selected numbers and standard check

Characteristics	Details	Total score	Accept score	04-116	04-129	04-161	04-171	04-297	04-329	P-CK
Growth Habit (25 points)	bush	5	5.0	5	5	5	5	5	5	5
	stem length	5	4.9	5	5	5	5	4	5	5
	bud union	3	3.3	4	3	3	3	3	4	3
	side shoots	3	2.9	3	3	3	3	2	3	3
	thorns	3	3.3	3	3	4	4	3	3	3
	sum	19	19.3	20	19	20	20	17	20	19
Problem on Field (25 points)	spiral center opening	4.1	4.0	4	5	5	3	2	5	4.1
	flower opening	3.6	3.5	5	5	2	5	2	2	3.6
	fading flower	4.1	4.2	5	5	5	3	2	5	4.1
	bent neck	4.6	4.5	5	2	5	5	5	5	4.6
	flower shape	4.7	4.7	5	5	5	4	4	5	4.7
	sum	21.1	20.9	24	22	22	20	15	22	21.1
Flower Characters (60 points)	beauty of un-opening stage	4.6	4.5	5	5	5	4	3	5	4.6
	beauty of semi-opening stage	4.6	4.5	5	5	5	3	4	5	4.6
	beauty of opening stage	4.7	4.7	5	5	5	3	5	5	4.7
	brightness of colour	4.4	4.2	4	4	4	4	4	5	4.4
	vividity of colour	4.4	4.2	4	4	4	4	4	5	4.4
	petal thickness	4	4.0	5	5	3	3	4	4	4
	petal texture	4.1	4.0	4	5	3	4	3	5	4.1
	straightness of stem	4.9	5.0	5	5	5	5	5	5	4.9
	proportion of stem and leaves	4.4	4.3	5	4	4	4	4	5	4.4
	glossiness of leaves	2.4	2.5	1	1	5	3	2	3	2.4
	size of flower	4.3	4.2	5	5	3	3	5	4	4.3
	number of petals	3.6	3.7	4	4	2	4	5	3	3.6
	sum	50.4	49.8	52	52	48	44	48	54	50.4
Productivity Trends (55 points)	uniformity of sprouting	4.4	4.3	5	4	4	4	5	4	4.4
	sprouting after bending	3.7	4.0	5	4	4	3	4	4	3.7
	sprouting after harvesting	4.6	4.7	5	4	5	4	5	5	4.6
	plant building	4.5	4.6	5	5	5	5	4	4	4.5
	flush to flush	4.5	3.2	3	3	3	3	4	2	4.5
	levels to propagation	4.4	4.3	5	5	5	3	5	3	4.4
	levels to bending	4.1	4.2	4	5	5	3	5	3	4.1
	productivity	3	3.1	2	3	3.5	2.5	4	3.5	3
	%CK	1.5	1.6	1	1.5	2	1	2	2	1.5
	%high/ low grade	3.7	3.7	4	4	2	4	4	4	3.7
	vase life	2.7	3.5	4	5	4	3	2	4	2.7
	transport	2.7	2.8	3	3	3	3	2	3	2.7
	sum	43.8	44.0	46	46.5	45.5	38.5	46	41.5	43.8

5 major characteristics were summarized and sorted to arrange priority of selected numbers. Two numbers with highest scores i.e. '04-116' and '04-129' were selected. 4 offspring with scores lower than the selected plants were discarded. Remaining 2 offspring with good characteristics of cut-rose were kept for the advanced sensory trial to compare with standard check (Table 4.58).

Table 4.58 Summary of 5 major characteristics of 6 pink offspring and standard check

Characteristics	Total score	Accept score	04-116	04-129	04-161	04-171	04-297	04-329	P-CK
Growth Habit	19.0	19.0	20.0	19.0	20.0	20.0	17.0	20.0	19.0
Problem on Field	21.1	20.9	24.0	22.0	22.0	20.0	15.0	22.0	21.1
Flower Characters	50.4	49.8	52.0	52.0	48.0	44.0	48.0	54.0	50.4
Productivity Trends	43.8	43.7	46.0	46.5	45.5	38.5	46.0	41.5	43.8
Total	134.3	133.3	142.0	139.5	135.5	122.5	126.0	137.5	134.3
Rank			1	2					
Discarded/Selected			Selected	Selected	Discarded	Discarded	Discarded	Discarded	CK

4.6 Market response trial

4.6.1 Customer information

Although the number of the two tester groups was different, the same proportion (6:4) was maintained i.e. 1) general public: 60% female and 40% male and 2) flower shops: 57% female and 43% male.

The component of the general public consisted of 4 age groups i.e. less than 20, 21-30, 31-40 and 41-50. In the general public group, the maximum number of people interviewed belonged to the 21-30 age groups while the minimum number was from the 41-50 year group. The florist category had 3 age groups i.e.21-30, 31-40 and 41-50.The less than 20 group was omitted because of the fact that this group normally was not in the flower business.

Two customer groups were different in the frequency of buying. The general public group bought flowers rather infrequently. Occasions when flowers were used mainly related to religious activities, even less for household decorations. The flower shop group consisted of regular buyers and florists. The regular buyers were middlemen and wholesalers who collected roses from growers and sold them to retailers. The florists, on the other hand, were not necessarily regular buyers and most of them did not keep a large number of roses in their shops. They would buy them whenever the works required roses.

Two customer groups had different sources for buying roses. The general public group needed a small number of rose at a time and bought them from fresh-food markets, flower shops and the Royal Project shop. The buying from market had the highest frequency because of the relatively lower price and convenience. The flower shop group needed a large number of roses and often bought from fresh-food market or direct from farms. Getting them at wholesale price gave a little more profit. Most florists had regular rose growers to buy from. Some florists and wholesalers even ran their own rose farms. Buak Chan and Buak Toey were the major rose farming areas which supplied roses to the flower markets of Chaing Mai as well as Bangkok. Cheaper transport cost (in the case of Chiang Mai market) and much higher quality gave them a good position in the upper market, compared with the rose from Phob Phra, Tak Province. Most flower shops bought fresh roses daily from the flower markets at wholesale price. How often and what number they bought depended on their daily demands (Figure 4.41).

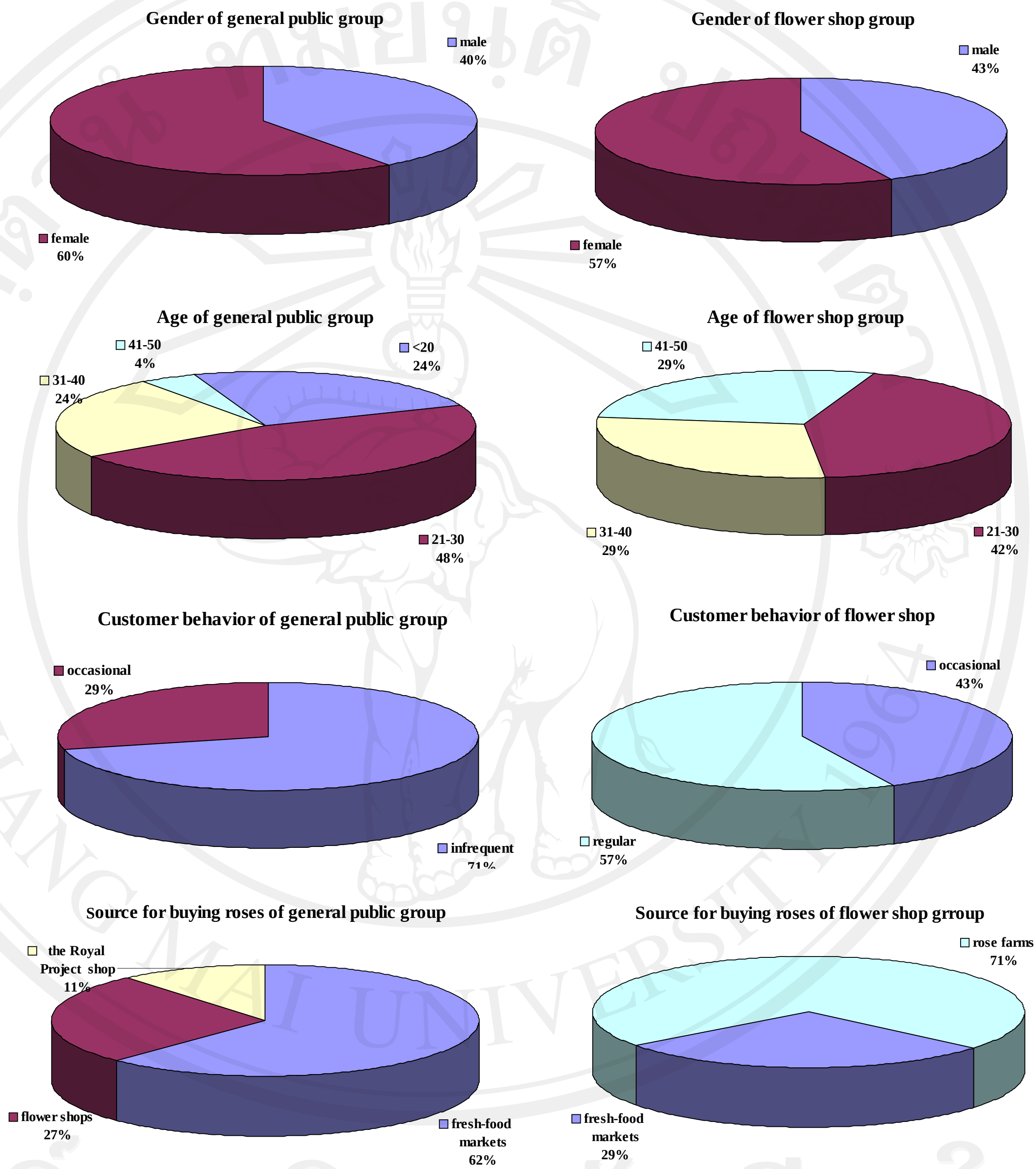


Figure 4.41 Information on market response from two customer groups

4.7.2 Customer response

4.7.2.1 Selected red rose

Selected red roses were judged from the 5 characters, i.e. flower size, flower shape, flower colour, petal texture and leaves. The responses were as follows: the general public acceptance of ‘04-301’was more than standard check, especially the glossy leaves, similar to the flower shop group (Figure 4.42A). Flower shops favored every characteristic of standard check over ‘04-301’, especially texture of petals but they liked glossy leaves of ‘04-301’ more than ‘R-CK’ (Figure 4.60B), while ‘04-318’was disfavored. From two acceptance ratings, it could be concluded that ‘04-301’ was suitable to be released as a new red rose variety because of good market response for its glossy leaves.

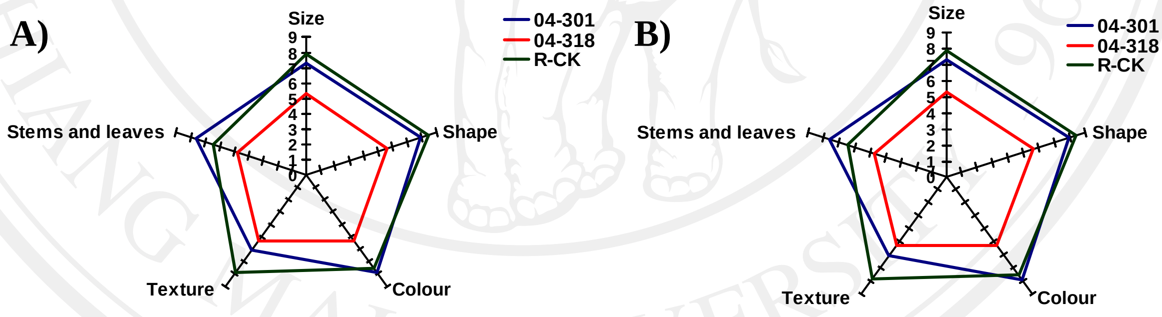


Figure 4.42 The weighted difference between the mean of each trait on polar plot for the comparison of sensory profile of 2 selected red offspring and standard check

A) General public B) Flower shop

Conclusion for the selected red rose was presented as follows: General public favored ‘04-301’ by 93% and standard check ‘R-CK’ by 76%, ‘04-318’ was rejected. Flower shops favored both of ‘04-301’ and ‘R-CK’ by 100%, while ‘04-318’was rejected by 71% (Figure 4.43).

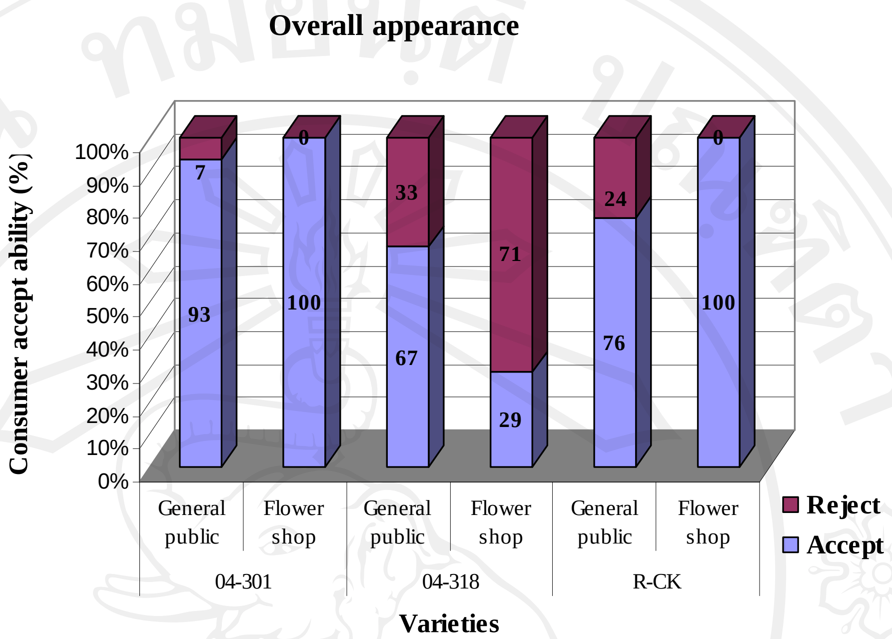


Figure 4.43 Market response of selected red rose

4.7.2.2 Selected pink rose

The impression of the general public and the flower shop was presented in Figure 4.44

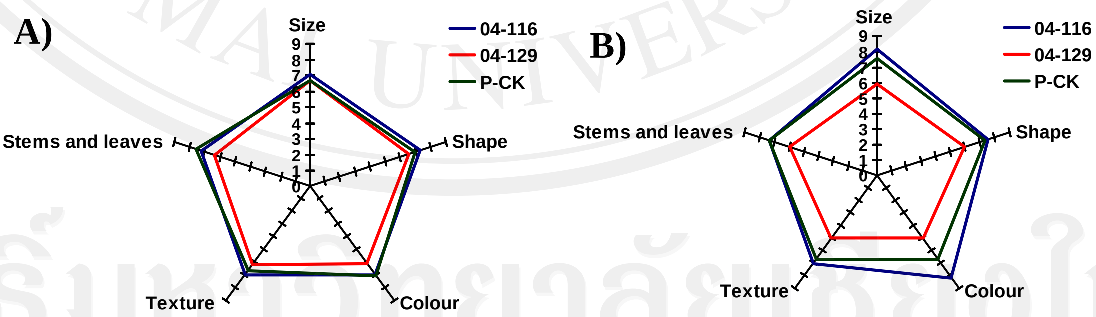


Figure 4.44 The weighted difference between the mean of each trait on polar plot for the comparison of sensory profile of 2 selected pink offspring and standard check.
A) General public B) Flower shop

For the general public, ‘04-116’ as well as the standard check had been accepted. Number ‘04-129’ was quite unfavorable to the general public while the flower shop selection favoured it over the standard check , and disfavoured ‘ 04-129’

It could be concluded that for the general public opinion, the standard check varieties got the highest popularity (91%) while the two selected varieties, 04-116 and 04-129 were 87 % and 80% respectively. However, for the flower shop opinion, 04-116 got the highest response, 100%. Number 04-129 received very low response, only 29% (Figure 4.45).

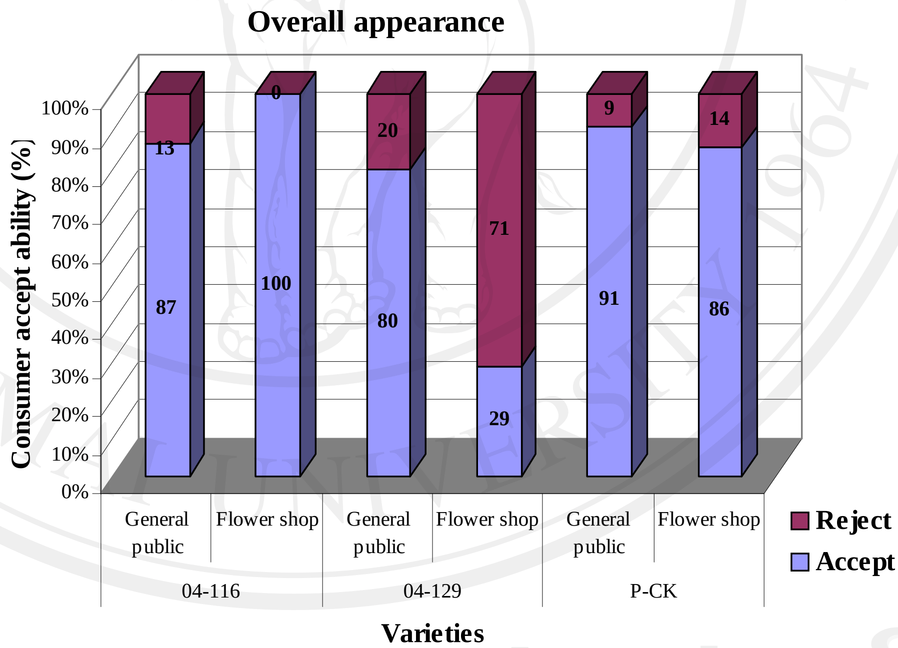


Figure 4.45 Market response of selected pink rose