Short Communication

A Genetical Factor Enhancing Plant Regeneration Linked with the \textit{V-v} Locus in \textit{Hordeum vulgare} L.

Takao Komatsuda\textsuperscript{1)}, Wenbin Lee\textsuperscript{2)}, Hiroshi Sato\textsuperscript{3)}, Toshio Anna\textsuperscript{4)}, Sueo Enomoto\textsuperscript{1)}, Minjung Kang\textsuperscript{1)} and Seibi Oka\textsuperscript{1)}

\textsuperscript{1)} National Institute of Agrobiological Resources, Kannondai, Tsukuba, Ibaraki, 305
\textsuperscript{2)} Northeast Agricultural College, Harbin, Heilongjiang Province, China
\textsuperscript{3)} Lotte Central Laboratory, Numakage, Urawa, Saitama, 160
\textsuperscript{4)} Tokimec, Minami-Kamata, Ohta-Ku, Tokyo, 144

A morphological marker locus was utilized to analyse the possible linkage with the ability of regeneration in barley. Callus formation and shoot differentiation were initiated from immature embryos of P\textsubscript{1}, P\textsubscript{2}, F\textsubscript{1} and F\textsubscript{2} plant populations from a cross between a six-rowed cultivar \times two-rowed cultivar. Broad sense heritability for the regeneration rate was 0.76, thus showing definite contributions of genetical factors to regeneration. Regeneration rate was associated with the character of kernel row number; plant regeneration was enhanced by gene(s) coupling with the \textit{V} allele on chromosome 2 from the two-rowed parent.

KEY WORDS: \textit{Hordeum vulgare} L., tissue culture, regeneration, immature embryo, callus, genetic control

Introduction

Genotypic differences are manifested by the ability of regeneration of callus from immature barley embryo (Hanze\textsuperscript{el} \textit{et al.} 1984, Lührs and Lörz 1987, Ohkos\textsuperscript{hi} \textit{et al.} 1991). Since regeneration is under genetic control as well as physiological control, the transfer of regeneration genes to ‘difficult’ cultivars or species is one way to improve the regeneration capacity. Genetic mapping for genes controlling the regeneraiton ability is thus required for achieving the new scheme.

It was pointed out in the extensive screening studies for barley regeneration from both immature embryo callus (Ohkos\textsuperscript{hi} \textit{et al.} 1991) and mature embryo callus (Taniguchi \textit{et al.} 1991) that two-rowed cultivars responded better than six-rowed ones to shoot differentiation. The number of kernel rows is predominantly controlled by a single locus, \textit{V-v} on chromosome 2 (LeBaron 1959, as cited by Niran 1964), and the genotype \textit{vv} has a six-rowed ear and \textit{VV} and \textit{Vv} a two-rowed ear. In this study, the relationship between the genotype for \textit{V-v} locus and the regeneration ability was investigated using an F\textsubscript{2} population.

Materials and Methods

Based on a previous screening study, ‘Azumamugi’ a six-rowed cultivar responded poorly to differentiation from immature embryo callus, whereas ‘Kanto Nakate Gold’ a two-rowed type showed a higher ability of regeneration (Ohkos\textsuperscript{hi} \textit{et al.} 1991). A diallel analysis rev-

Received August 14, 1991.
ealed that among seven tested cultivars Azumamugi was most recessive and Kanto Nakate Gold most dominant for regeneration (Komatsuda et al. 1989).

F₁ plants were obtained from a cross between Azumamugi (P₁) and Kanto Nakate Gold (P₂), and single F₁ plant was self-pollinated to produce F₂ plants. To identify the genotype, seventy-three F₂ plants and 10 F₃ progeny from each F₂ plant were evaluated for the morphological character; the number of kernel rows (V-v locus). Thirty immature embryos from each of the 26 P₁, 23 P₂, 15 F₁ and 73 F₂ plants were cultured for callus initiation and evaluated for the percentage of callus differentiating shoot according to the methods of Komatsuda et al. (1989). In this study regeneration ability of each of F₁ and F₂ plant was evaluated by the regeneration rate of its immature embryos on the plant, (F₂ and F₃ generations, respectively) because regeneration rate is of threshold characters such as germination rate of seeds, and hence regeneration ability of the heterozygote is evaluated by the mean of the progeny. All data underwent arcsin (\(\sqrt{p}\)) transformation to improve the normality of the distribution. Broad sense heritability was estimated as \((\bar{v}_{F₂}-\bar{v}_{F₁})/\bar{v}_{F₁}\). Relationship between genotype at the V-v locus and regeneration rate was investigated.

**Results and Discussion**

Regeneration data for four populations are presented in Fig. 1. The largest variance was observed in the F₂ population, and the variance significantly differed from that of P₁, P₂, and F₁ in F-test. Broad sense heritability was 0.76 in the F₂ population, thus representing a major contribution of genetic factors to regeneration.

In the F₂ population, alleles at the V-v locus segregated into 21:28:24 for \(VV:Vv:vv\). The ratio did not deviate significantly from the expected 1:2:1 ratio (0.1 < \(P<0.2\)). Means of the regeneration rate of both homozygous P₂ type genotype (VV) and heterozygous genotype (Vv) significantly differed from that of homozygous P₁ type genotype (vv) in \(t\)-test (Fig. 2).

The association of regeneraiton ability with V-v genotype revealed the presence of a significant positive effect of one or more genes enhancing regeneration from callus. The gene(s) will be coupled with the V gene on the chromosome 2 from Kanto Nakate Gold. The enhancement of regeneration rate is not the pleiotropy of V gene, because a high percentage of shoot differentiation from immature embryo-derived callus was recognized in some plants of \(vv\) genotype and no differentiation in some plants of VV genotype in anther culture-derived doubled haploid lines prepared from the same cross combination as in this study (Komatsuda, unpublished data).

Recently two dominant genes controlling regeneration ability have been identified for the first time in tomato (Koornneef et al. 1987) and found to be located on the linkage map (Koornneef and Hanhart 1990). Our study detected one or more genes enhancing regeneration ability, which is linked with a morphological marker gene V-v in barley. A detailed mapping of the genes on the barley genome is under way.

**Acknowledgements**

The authors acknowledge the helpful comments of Prof. Dr. S. Yasuda, Okayama Univer-
Fig. 1. Distributions of regeneration rate (transformed to arcsin √) of immature embryo-derived callus in parents, F₁ and F₂ plants from a cross Azumamugi × Kanto Nakate Gold. Means followed by a same letter are not significantly different at 5% level of t-test.

sity, and Dr. Y. Ukai, National Institute of Agro-Environmental Sciences.

Literature Cited

HANZEL, J. J., J. P. MILLER, M. A. BRINKMAN and E. FENDOS 1984. Genotype and media effects on
callus formation and regeneration in barley. Crop Sci. 25: 27–31
KOORNNEEF, M. and C. J. HANHART 1990. The genetics of regeneration capacity in tomato. 7th Int. Congr. Plant Tissue Cell Cult. B647. p300

オオムギの植物体再生分化性を高める遺伝因子とV-v 遺伝子座との連鎖

小松田隆夫1), 李 文演2), 佐藤 洋3), 安中敏男4), 櫻本英男5), 姜 玲玲6), 岡 成美1)

(1)農業生物資源研究所, 奈良県つくば市観音台, ☎ 365
(2)東北農学院, 中国黒龍江省ハルビン市
(3)ロッテ中研, 埼玉県浦和市沼田, ☎ 160
(4)トキメック, 東京都大田区南浦田, ☎ 144

オオムギにおいて未熟胚由来カルスからの植物体再生能は平均して二条オオムギが六条オオムギより高いと報告されている。そこでオオムギの植物体再生能と小穂の条状に関する遺伝子座V-vとの連鎖関係を分析した。分化能の低い六条品種アズマムギと高い二条品種関東中生ゴールドを交配し、両親、F₁、F₂の各植物体上の自殖で生じた未熟胚からカルスを誘導し、カルスからの植物体再生分化率を求めた。広義の遺伝率は0.76と高く、この実験系では遺伝的要因が再生分化に大きく寄与していることがわかった。F₂植物集団の再生分化率は小穂の条状（V-v遺伝子座）と明らかに関連があり、二条の個体（VVあるいはVv）は六条の個体（vv）よりも平均して有意に高かった。交配した親品種の間の再分化能の差は第2染色体上のV-v遺伝子座と連鎖する一または複数個の遺伝子の働きによるもので、二条品種に由来する遺伝子（群）が再分化能を高める方向に作用すると考えた。