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# INDUCTION, INHERITANCE PATTERN AND AGRONOMIC PERFORMANCE OF AWNED MUTANTS IN A MULTIPLE DISEASE RESISTANT BREAD WHEAT CULTIVAR

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## ABSTRACT

**Awning was induced in a 1RS-1BL awnless bread wheat cultivar 'CPAN 1922' through gamma-irradiation at 3 doses (10, 20 and 30 kR). In $M_2$ generation, 10kR gave the highest mutation frequency and was the most effective as well as efficient treatment for inducing awnedness. The parent variety is indicated to possess a single dominant awn inhibitor $B_1$. Four promising fully-awned mutants were agronomically evaluated in $M_3$ and $M_4$ generations for grain yield/plant, plant height, tillers/plant, spike length, spikelets/spike, grains/spike and 1000-grain weight. Of these, an agronomically superior mutant has been identified.**

**Key words :** Awn inhibitors, $B_1$ and *Q* loci, mutagenic effectiveness and efficiency, *Triticum aestivum*

The presence of awns in bread wheat (*Triticum aestivum* L. em Thell) provides a larger surface area available both for light interception and $CO_2$ uptake which may double the net photosynthetic rate of wheat ears [1]. Awning is also reported to offer a yield advantage upto 13% [2] particularly under drought stress because the transpiration ratio of awns is several times greater than that of the leaves and glumes [3, 4]. Acreman and Dixon [5] have reported awning to reduce the grain aphid (*Sitobion avenae*) population to the extent of one third of that observed on awnless plants. The awned mutants have also been reported to be useful in the development of more truely isogenic lines [6].

A bread wheat introduction from CIMMYT, CPAN 1922 with a pedigree (Ore, $F_1$, 158-Fld/Mexifen "S"/Tib.63/Coc. 75) possesses various desirable traits like good tillering, lodging reistance due to stiff culm, amber grains and resistance to most of wheat diseases. It carries *Yr9, Lr26, Sr31* and *Pm8* genes conferring resistance to

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yellow rust, leaf rust, stem rust and powdery mildew respectively derived from rye due to 1RS-1BL translocation [7, 8]. Sudhakar and Joshi [9] have reported the presence of additional gene for leaf rust resistance (*Lr3*) in CPAN 1922. Notably, these alien genes might impart a higher level of resistance against wheat pathogens. However, this cultivar could not become popular primarily due to its awnless nature. These considerations promoted us to undertake mutagenesis for awning in this cultivar and to evaluate the awned mutants, if induced.

## MATERIALS AND METHODS

Dry and healthy seed samples of wheat cultivar CPAN 1922' containing 600, 700 and 800 seeds were gamma-irradiated at 10, 20 and 30 kR doses, respectively in the 60-Co gamma Cell (dose rate 6.5 kR/min.). The treated seeds were sown to raise the $M_1$ generation at Palampur during *rabi* season and recommended agronomic practices followed. The harvested $M_1$ spikes were sown as spike-to-row progenies to raise the $M_2$ generation. In $M_2$, the mutation frequency for awning, mutagenic effectiveness and efficiency were calculated as per Konzak *et. al.* [10].

The isolated mutants along with their normal sibs were sown as progeny-rows in the $M_3$ generation. Data on 10 random plants of the true breeding mutants were recorded for various plant traits including grain yield. In $M_4$ generation during *rabi* 1990- 91 four promising and true breeding awned mutants were evaluated in a randomized block design with three replications.

## RESULTS AND DISCUSSION

### MUTATION INDUCTION

No awned variant was observed in the $M_1$ population. In $M_2$, on the basis of $M_1$ spike progenies and $M_2$ plants, the 20 kR and 10 kR treatments, respectively

**Table 1. Measures of biological damage in $M_1$ generation**

| Dose (kR) | Seedling height reduction (H) % | lethality (L) % |
|---|---|---|
| 10 | 6.37 | 24.31 |
| 20 | 31.2 | 29.74 |
| 30 | 36.51 | 55.20 |

gave the highest mutation frequency, effectiveness as well as efficiency (Table 2). Mutagenic effectiveness refers to the per cent mutation frequency observed in the $M_2$ divided by the radiation dose applied, whereas mutagenic efficiency is the per cent mutation frequency divided by the extent of plant damage/lethality in the $M_1$ generation. Therefore, the most effective dose is the one which causes highest $M_2$ mutation frequency per unit of the mutagen tested whereas the most efficient dose causes highest mutation frequency with the least plant damage in the $M_1$ generation. For calculating mutation frequency on the $M_1$ plant progenies and $M_2$ population basis, Gaul [11] has recommended dependence on the $M_2$ population since this takes into account even the same type of mutation occuring more than once in a spike. Moreover, mutation frequency remains unaltered by the size of the mutated sector in a spike and tiller number of $M_1$ plants. Therefore, among the three doses tested

**Table 2. Mutation frequency, mutagenic effectiveness and efficiency for induced awning in CPAN 1992**

| Dose | 10kR | | | | 20kR | | | | 30kR | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Frequency(%) | Effectiveness | Efficiency | | Frequency(%) | Effectiveness | Efficiency | | Frequency(%) | Effectiveness | Efficiency | |
| Based on | Ms | Ms/10 | Ms/H* | Ms/L | Ms | Ms/20 | Ms/H | Ms/L | Ms | Ms/30 | Ms/H | Ms/L |
| $M_1$-spike progenies | 0.74 | 0.07 | 0.12 | 0.03 | 3.29 | 0.16 | 0.10 | 0.11 | 1.62 | 0.05 | 0.04 | 0.03 |
| $M_2$-plants | 0.27 | 0.03 | 0.04 | 0.02 | 0.23 | 0.01 | 0.01 | 0.01 | 0.28 | 0.01 | 0.01 | 0.01 |

*Table 1 for H and L

in CPAN 1922, 10 kR appears to induce the highest mutation frequency and to be the most effective as well as efficient treatment for inducing awning.

## INHERITANCE AND THE PRESENCE OF AWN INHIBITOR(S):

The normal sibs of only one $M_2$ awned mutant (Mutant-16) segregated in $M_3$. Out of 48 plants in $M_3$, 39 exhibited normal awnless and 9 fully awned phenotypes. This type of segregation conforms to the hypothetical 3:1 ratio ($X^2 = 1.000$, $0.30<P<0.50$) suggesting that the mutant trait is monogenic recessive. The presence of four dominant awn inhibitors *viz* $B_1$, $B_2$, *Hd* and $B_3$ located respectively on 5AL, 6BL, 4BS and 1DL chromosomes has been reported [12]. Bhatia and Swaminathan [13] have reported that in general the European and North American beardless wheats seem to possess the inhibitor $B_1$ and the Asiatic wheats the inhibitor $B_2$. Since CPAN 1922 belongs

**Table 3. Agronomic performance of fully-awned mutants of CPAN 1922 in $M_3$ and $M_4$ generations**

| Mutant | Phenotype | Plant height (cm) | Tillers/ plant | Spike length (cm) | Spikelets/ spike | Grains/ spike | 100-grain weight (g) | Grain yield/ plant(g) | Harvest index (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | *$M_3$ generation* | | | | | |
| M-5 | Awned, dwarf | 58.0±3.36-* | 1.50±0.22 | 8.40±0.36 | 13.60±1.03 | 41.7±3.96 | 4.06±0.28+ | 2.43±0.56 | - |
| M-6 | Awned, dwarf | 55.8±1.98- | 2.60±0.16+ | 8.80±0.30 | 13.00±0.73 | 35.0±0.55– | 3.30±0.28 | 2.33±0.24 | - |
| M-10 | Awned, speltoid | 69.7±1.41 | 2.40±0.27+ | 10.02±0.19+ | 16.20±0.33+ | 47.0±1.35 | 3.31±0.24 | 3.33±0.41 | - |
| M-16 | Awned | 68.2±1.18 | 2.67±0.32+ | 8.02±0.28 | 11.40±0.65– | 38.2±2.14– | 3.31±0.10 | 3.67±0.46+ | - |
| Control | | 69.3 ±0.48 | 1.81±0.024 | 8.52±0.09 | 13.60±0.23 | 45.8±1.04 | 3.08±0.06 | 2.75±0.21 | - |
| | | | | *$M_4$ generation* | | | | | |
| M-5 | Awned, dwarf | 69.7– | 1.53 | 10.13+ | 16.73 | 40.0– | 4.35+ | 1.98 | 33.49 |
| M-6 | Awned, dwarf | 58.9– | 2.23+ | 8.70 | 16.70 | 35.7– | 3.36 | 2.39 | 33.60 |
| M-10 | Awned, speltoid | 73.7– | 1.40 | 9.13 | 16.27 | 31.2– | 2.26– | 1.26– | 28.17– |
| M-16 | Awned | 83.5+ | 2.03+ | 8.93 | 14.67 | 34.1– | 3.80+ | 2.75 | 30.00– |
| Control | | 79.1 | 1.51 | 8.57 | 14.73 | 51.6 | 3.20 | 2.42 | 36.11 |
| C.D. (5%) | | 4.27 | 0.26 | 0.89 | 2.22 | 8.58 | 0.60 | 0.45 | 2.97 |

*+Significantly higher than the control at 5% level, –Significantly lower than the control at 5% level

to the former group, it might be therefore carrying the inihibitor $B_1$. The variety resembles in many respects with the variety NP 809 (in which inhibitor $B_1$ was detected) used for inducing awnedness by Bhatia and Swaminathan [13]. Both these varieties are long tipped, late maturing and the genetic analysis of the NP 809 fully awned mutants also revealed the monogenic-recessive control of awning. Cytological studies of the NP 809 mutants by Natarajan *et al.* [14] indicated either a cryptic deletion or a point mutation for the $B_1$ locus. SInce no reverse mutation was observed in the progenies of mutants following re-irradiation, the deletion hypothesis is more probable. The deletion hypothesis further gets substantiated by the fact that radiations as used by Bhatia and Swaminathan [13] and in the present study also, principally cause chromosomal aberrations, whereas chemical mutagens mostly induce gene mutations. Furthermore, since $B_1$ and $Q$ loci are both located on 5AL, deletion involving both these loci is possible which has occured in the present study resulting in the production of a bearded speltoid mutant (Mutant-10) as also reported by Georgiev and Nikolov [15]. Therefore, it is quite possible that CPAN 1922 carries a single epistatic dominant gene $B_1$ as an inhibitor of awning.

## AGRONOMIC PERFORMANCE OF MUTANTS

In the $M_3$ generation, 4 awned mutants (M-5, M-6, M-10 and M-16), appeared to be promising (Table 3). The mutant M-5 was dwarf and exhibited higher 100-grain weight over control. The mutant M-6 was dwarf with more tillers/plant but lesser grains/spike. Tillers/plant, spike length and spikelets/spike were higher in the speltoid mutant M-10. Snape *et. al.* [16] also reported the effect of locus causing speltoidy on the spike length and spikelets/spike. They also reported such mutants to be of practical interest due to their higher protein content (18.5%). The mutant M-16 gave significantly higher yield (3.67 gm) with more tillers than the control but had lesser spikelets and grains/spike.

Further evaluation of these mutants in replicated $M_4$ generation revealed that mutant M-5 still maintined its dwarfness and higher 100-grain weight with increased spike length and reduced grains/spike. As in $M_3$ generaiton, M-6 was still dwarf with more tillers/plant and lesser grains/spike. The grain yield and the harvest index of the mutant M-10 were reduced due to lesser grains/spike and 100-grain weight. The grain yield of mutant M-16 being significantly higher (133%) in the $M_3$ generation turned out to be comparable (113%) with the control in the $M_4$ generation. Therefore, mutant M-16 appears promising after being tested under different agro-climatic conditions.

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