SEED VIGOR AND PRODUCTIVITY[1]

TARCISO S. FILGUEIRAS[2]

ABSTRACT - Seedling vigor is deeply related to productivity to the extent that high vigor seeds are expected to form better stands and produce higher yields. Seed vigor is here broken down in the following components: seed maturity, seed size, nature of food reserve, seed deterioration and seed-borne pathogens. Each component is briefly dealt with and its implication in productivity discussed. It is recommended the use of high vigor seed lots and suggestion is made to the seed companies to use vigor as a competition weapon.

Index terms: seed vigor, productivity.

VIGOR DE SEMENTES E PRODUTIVIDADE

RESUMO - O vigor da plântula está profundamente relacionado com a produtividade da cultura. Sementes de alto vigor devem formar melhores stands e apresentar melhor rendimento. O vigor da semente é aqui desdobrado nos seguintes componentes: maturação, tamanho, natureza das reservas, deterioração, patógenos transmitidos pela semente. Cada componente é comentado ligeiramente e discutida sua implicação na produtividade. Recomenda-se o uso de sementes de alto vigor e sugere-se que as companhias de sementes usem "vigor" como um fator crítico na competição comercial.

Termos para indexação: vigor de semente, produtividade.

INTRODUCTION

Seedling establishment in the field is intensely competitive. A number of factors, such as rapidity of germination and rate of development may determine which seedlings survive to maturity.

Seedling vigor can be seen as the ability of a seedling to establish well and thrive under stress conditions. Seen under this light, seedling vigor is deeply related to productivity to the extent that high vigor seeds are expected to form better stands, establish themselves faster, and produce higher yields (McDonald Junior 1975).

DEVELOPMENT

Yield of a crop is a summation of a number of yield components, e.g., number of plants per unit area, number of seeds per head or pod and seed size (seed weight) (Adms 1976).

Many factors influence the success of crop production: soil type, management practices, fertilizing programs, weed control, weather, seed used, etc. The quality of the seed used for planting purposes is of primary importance in obtaining a stand and its subsequent productivity.

Seed quality is made up of many factors, such as purity, germination, freeness from disease-causing organisms, and vigor. Of all these factors, seed vigor is perhaps the least recognized and the least understood, though it too can affect crop production as surely as weeds, insects and diseases (Grabe 1972).

Farmers have traditionally relied on germination as a key quality factor. Germination, however, cannot be the only parameter of seed quality. Normally too much is expected from a germination test. The test is performed to obtain information for labeling purposes and to determine whether seed meets certification standards or contract specifications. There are many performance traits that a mere germination test cannot indicate. For instance, it does not tell what types of stands to expect under adverse conditions, aged or cracked seeds, etc.

If these questions are to be answered, the seed has to be tested for its vigor and performance potential.

Broadly speaking, seed vigor may be defined as having a genetic component and an environmental component. The genetic component represents the maximum performance of a variety (result of hybridization, selection and variety development).

1 Accepted for publication on April 22, 1981.
This work was presented as partial fulfillment for the requirements of the M.S. at the Oregon State University, USA.

2 Eng.º Agr.º, M.Sc., Reserva Ecológica do IBGE, Ed. Venâncio II, 1.º andar, CEP 70302 - Brasília, DF.

The environmental component is represented by fertilization practices, weather, mechanical damage, storage conditions, etc.

Seed vigor in its environmental aspect includes the following factors:

Seed maturity

The general conclusion that can be drawn from the vast literature on seed maturity is that the more mature the seed harvested, the greater its vigor (Pollock & Ross 1972). Helmer et al. (1962) suggested that seeds reach maximum quality at physiological maturity, and that from that time until planting only degenerative changes occur, the rate being dependent upon the degree of deviation from optimum conditions. Physiological maturity normally coincides with maximum dry weight that the seed attains.

The problem of when to harvest a seed crop in order to obtain maximum vigor can be both conceptual and practical. Normally, each seed field consists of plants with seeds in different stages of maturity. Harvesting too early or too late results in seeds of low vigor and production potential.

Seed size

Seed size is another obvious component of seed vigor. The literature dealing with a large number of crops (including wheat, barley, lima beans, snap beans) supports the fact that larger seeds give rise to more vigorous plants and better yields, particularly when equal number of seeds per unit area are planted (Bramner et al. 1963, Clark & Peck 1961, Filgueiras 1977, Kaufman & Guitard 1967, Wester 1964).

Contradictory results have also been reported. Hicks et al. (1976) found that seed grade had no effect on corn yield when data were averaged over years, locations and hybrids. By the same token, Dhillon's (1973) work on soybeans at Ohio State University indicates that there is no justification in grading the soybean seed, and using the large seed with the idea of obtaining bigger plants and yield. In fact, his data show that it is possible to obtain similar yields by using smaller seeds rather than larger seeds. On the other hand, seed size usually has a definite effect in seedling vigor of horticultural crops. Ching & Danielson (1972) found a direct correlation between seed size and seedling vigor in lettuce. Scaife & Jones (1970), working with the same species under uniform conditions and absence of inter-plant competition, found a linear relationship between the fresh weight of the plant top at harvest and the weight of the seed sown. Hanumaiah & Andrews (1973) also report growth and vigor of seedling of both cabbage and turnips increased as seed size increased. Our own data (Filgueiras 1977) on snap bean show that seeds grown at low density produced 10% and 23% more pods than seeds grown at medium and high densities, respectively.

Nature of the food reserves

Lopez & Grabe (1972) reported that high protein seeds of wheat and barley developed into larger seedlings with higher dry matter content when grown in N deficient soil. A significant positive correlation between wheat seed protein content and dry matter after three weeks of growth was also reported by Lowe & Reis (1972).

Reis et al. (1971) reported that increases in seed protein due to both herbicide and N application were reflected in higher yields the next generation. Interestingly enough, yield was directly correlated with seed protein content but not with seed size. Seedling size, yield and number of fruits were reported by Reis (1970) to be more highly correlated with protein per seed than with seed size in beans.

Lots remained to be learned about the effect of protein, phosphorus, and trace elements (Mo, Bo, Zn, etc.) content of seed. This is a potential area of seed quality research that awaits investigation.

Seed deterioration

Seed deterioration refers to any irreversible degenerative change in the quality of a seed after it has reached its maximum quality level (Abdul-Baki & Anderson 1972). So, after seed has reached its maximum quality and is not harvested, it has actually been stored under field conditions.

Poor stands may result from planting seeds that have deteriorated from aging, mechanical damage and other causes.

Among the many physiological manifestations of seeds deterioration are changes in seed color, delayed germination, decreased tolerance to sub--optimum conditions during germination, reduced seedling growth, reduced germinability, and increased number of abnormal seedlings (Abdul--Baki & Anderson 1972). The implication of the above statement is that normally germination is still in a high level while vigor is in a much lower one. This is one of the risks involved when seed quality is evaluated only in terms of germination.

Poor stands from low vigor seed lots are especially prevalent when field conditions are sub--optimal. Stand differences may or may not affect yield, depending on the crop in question and the extent of stand reduction. Good fertilizer and irrigation practices are usually good measures to overcome vigor deficiencies in the field.

Seedborne pathogens

In most cases, the quality of a seed lot is not only genetic, physical and physiological but it is also phytosanitary. The presence of disease-causing bacteria, fungi, and viruses on and in seeds of crops like soybeans, beans, lettuce, ryegrass, among others, affect germination, seedling emergence and vigor, stand establishment, yield, and represent a potential danger of spreading the disease to the next generation and to new areas.

Yield reduction of more than 40% has been recorded when bean seeds contaminated with BYMV and BCMV were used (Hampton 1975). On the other hand, yield increases of more than 200% were obtained with the use of virus-free seed (Galvez 1976).

For some crops, the production of disease--free seed is a very promising way to promote seed vigor and yield potential.

CONCLUSIONS

1. The effects of seed vigor are frequently very subtle. Differences in stand density may be easily detected but 10 to 15% reduction in yield is not. The effect of vigor on crop production can only be measured by conducting carefully controlled trials. On the other hand, the detrimental effects of low quality seeds can be reduced by increasing seed rates to obtain satisfactory stands.

2. Seed vigor is especially important when we "plant to a stand", i.e., when each single seed must germinate and produce a plant, all plants in the field must grow to a uniform rate so that the crop can be harvested simultaneously in a once-over machine operation. This is the case with horticultural crops like lettuce, tomatoes, carrots, among others. Stand failure or lack of uniformity in readiness to harvest means lower yields and less profits to the grower.

3. It is our own feeling that farmers should be encouraged to use high vigor seeds. It is also our feeling that seed should be sold based on its performance potential so seed companies could use seed vigor (and other quality factors as well) as a competition weapon.

REFERENCES

ABDUL-BAKI & ANDERSON, J.M. Physiological and biochemical deterioration of seeds. In: KOZLOWKI, T.T. Seed biology. New York, Academic Press, Inc., 1972. p.283-315.

ADAMS, M.W. Basis of yield component compensation in crop plants with special references to the field bean, *Phaseolus vulgaris.* Crop Sci., 7:505, 1976.

BRAMNER, P.M.; ECKERSHALL, R.N. & SCOTT, R.K. The relative importance of embryo size and endosperm size in causing the effects associated with seed size in wheat. J. Agr. Sci., 61:139-45, 1963.

CHING, T.M. & DANIELSON, R. Seedling vigor and adenosine triphosphate level of lettuce seeds. Proc. Assoc. Off. Sedd Anal., 62:116-24, 1972.

CLARK, B.E. & PECK, N.H. Relationship between the size and performance of snap bean seeds. New York, s.ed., 1961. (Agr. Exp. Sta. Bull., 819).

DHILLON, G.S. Effect of seed size on the growth, yield, and composition of soybean (*Glycine max* (L.) Merr.), Colombus, Ohio, Ohio State University, 1973. Tese Doutorado.

FILGUEIRAS, T.S. Effect of variety, planting date and plant population on yield and quality of snap bean (*Phaseolus vulgaris* L.) seeds. Corvallis, Oregon, Oregon State University, 1977. 71p. Tese Mestrado.

GALVEZ, G.E. Establishment of a program in Brazil for producing disease-free seed of beans (*Phaseolus vulgaris.* Mississippi, s.ed., 1976, 20p.

GRABE, D.F. Components of seed vigor and their effect of plant growth and yield. s.l., s.ed., 1972. p.57.

HAMPTON, R.O. Bean yellow and bean common mosaic viruses. Phytopathology, 65:1342-6, 1975.

HANUMAIAH, L. & ANDREWS, C.H. Effect of seed size in cabbage and turnip on performance of seeds, seedling and plants. Proc. Assoc. Off. Seed. Anal., 63:117-25, 1973.

HELMER, J.D.; DELOUCHE, J.C. & LIENHARD, M. Some indices of vigor and deterioration in seeds of crimson clover. Proc. Ass. Off. Seed. Anal., 52:154, 1962.

HICKS, D.R.; PETERSON, R.H.; LEUESHEN, W.E. & FORD, J.H. Seed grade effect on corn performance. Agronomy, 2(68):819-20, 1976.

KAUFMAN, M.L. & GUITARD, A.A. The effect of seed size on early plant development in barley. Can. J. Plant Sci., 47:73-8, 1967.

LOPEZ, A. & GRABE, D.F. Effect of protein content on seed performance in wheat. (*Triticum aestivum* L.). s.l., s.ed., 1972. (Agr. Exp. Sta. Tech. Paper, 37).

LOWE, L.B. & REIS, S.K. Effects of environment on the relationship between seed protein and seedling vigor in wheat. Can. J. Plant. Sci., 42:157-64, 1972.

MCDONALD JUNIOR, M.B. A review and evaluation of seed vigor tests. Proc. Assoc. Off. Seed. Anal., 65: 109-39, 1975.

POLLOCK, B.M. & ROOS, E.E. Seed and seedling vigor. In: KOZLOWSKI, T.T. Seed biology. New York, Academic Press, 1972. p.314-87.

REIS, S.K. The relationship of size and protein content of bean seed with growth and yield. J. Am. Soc. Hort. Sci. 96:557-60, 1970.

REIS, S.K.; MORENO, O.; MEGGITT, W.F.; SCHWEITZER, C.J. & ASHKAR, S.A. Wheat seed protein: chemical influence on and relationship to subsequent growth and yield in Michigan and Mexico. Agron. J., 62:746-8, 1971.

SCAIFE, M.A. & JONES, D. Effect of seed weight on lettuce growth. J. Hort. Sci., 45:299-302, 1970.

WESTER, R.E. Effect of seed size on plant growth and yield of Fordhook 242 bush lima bean. Proc. Am. Soc. Hort. Sci., 84:327-31, 1964.