INFLUENCE OF PRE-EMERGENCE HERBICIDES ON GROWTH AND YIELD OF *PHASEOLUS VULGARIS* L. AND *P. COCCINEUS* L.

by

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Summary

Variable tolerance to herbicides has been reported amongst cultivars of several crop species, including: dry beans (*Phaseolus vulgaris* L. and *P. coccineus* L.), maize (*Zea mays* L.), soybean (*Glycine max* L.), sunflower (*Helianthus annuus* L.), rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.). De Beer (1988) reported that several dry bean plantings suffered from acetanilide herbicide injury during the 1982/83 season. Mennega, Nel & Le Court de Billot (1990) and Fouché (1996) have also reported differences in herbicide tolerance between dry bean cultivars grown in South Africa. Due to these expected differences in herbicide tolerance between local dry bean cultivars a study was undertaken to evaluate the influence of selected pre-emergence herbicides

on: a) the growth and yield of ten dry bean cultivars; b) seed yield on four soil types; c) to evaluate the use of chlorophyll *a* fluorescence as a technique for screening the herbicide tolerance of dry bean cultivars; d) dry bean morphology and cell ultrastructure, and e) to set guidelines for routine assessments of the herbicide tolerance of dry bean cultivars. The tolerance (plant growth and seed yield) of dry bean cultivars to pre-emergence herbicides was investigated in a field trial at the Grain Crops Institute of the Agriculture Research Council (ARC) in Potchefstroom (North West Province) during the 1996/97 growing season. Tolerance (based on seed yield) of the dry bean cultivar Helderberg to pre-emergence herbicides was investigated in a field trial in each of the districts Chrissiesmeer, Lichtenburg, Potchefstroom and Reitz during 1996/97. Chlorophyll *a* fluorescence was measured on the primary leaves and first trifoliate leaf of cultivars Kranskop and OPS-RS1 21 days after planting, after a dark adaptation period of 25 min., with a fluorescence measuring system (Plant Efficiency Analyser, Hansatech, UK). Cultivar Helderberg was grown in a glasshouse for 14 days. Completely unfolded leaves from one replicate were sampled and cut into ultra-thin sections to study cell structure by means of transmission electronmicroscopy. The two red speckled sugar bean cultivars (Kranskop and Monati) and Alubia cultivar (Cerillos) were significantly less tolerant than the small white (Helderberg and Teebus), yellow haricot (Katberg) and large white kidney bean (SSN1) cultivars. The latter cultivar was the most tolerant. The dry bean cultivars were significantly more tolerant to dimethenamid, imazethapyr and metazachlor than to flumetsulam + metolachlor or metolachlor. The 2x-rate caused an overall significant reduction in seed yield. For aboveground dry mass the two red-

speckled sugar bean cultivars (Kranskop and Monati) and the Alubia cultivar (Cerillos) were less tolerant than the other seven cultivars. Cultivar SSN1 was once again the most tolerant. The only significant (P = 0.05) reductions in yield of cultivar Helderberg were caused by flumioxazin at field sites Lichtenburg and Reitz. Dimethenamid, flumioxazin, flumetsulam + metolachlor and metazachlor caused significant decreases in Fo of the primary leaves of Kranskop. For the same cultivar, metazachlor had a similar effect in the first trifoliate leaf. Flumioxazin was the only herbicide to decrease the Fo of the primary leaves of OPS-RS1 significantly. Both dimethenamid and flumioxazin caused significant decreases in Fo of the first trifoliate leaf of OPS-RS1. Slight increases in Fo by imazethapyr, metazachlor and metolachlor were recorded on the primary leaves of OPS-RS1, but these increases were not significant. The Fv/Fm ratio of the primary leaves was significantly increased by flumioxazin, flumetsulam + metolachlor and metazachlor. Furthermore, irrespective of herbicide / cultivar combination used, or perturbation caused in the Fo and / or Fv/Fm fluorescence ratios, as long as the latter was statistically significant, the Fm values stayed essentially the same or decreased. These significant decreases in Fo and significant increases in Fv/Fm are typical of herbicides acting at site 2 of photosynthesis. Further research regarding the extent to which herbicides might be expected to influence yield is suggested. The electronmicroscopy study indicated ultrastructural changes in leaves treated with various herbicides. None of the herbicides caused drastic changes in the structure of chloroplasts. Except for imazethapyr, herbicides did cause a reduction in the number of stroma and granum lamellae. With the exception of imazethapyr-treated plants, starch

granules in treated plants appeared depleted and were rounder in shape than those of the control plants. Disruption of mitochondria was characterized by swollen and chaotically arranged crystae, except in imazethapyr-treated plants. These changes are probably manifestations of acetyl-Co enzyme A (CoA) inhibition which is needed in the formation of chlorophyll, and is an important part of the mitochondria-based Krebs cycle. As a result both photosynthesis and respiration efficiency will be influenced negatively, which in turn will have an adverse effect on plant growth and yield. Morphological changes included shorter and distorted stem growth; smaller leave size, and hence, less photosynthetic surface area. As expected, imazethapyr caused the least changes; and dimethenamid, metazachlor or metolachlor the largest. This study confirmed the existence of differential tolerance to herbicides amongst *P. vulgaris* and *P. coccineus* cultivars. More research, especially field trials, should be conducted to identify high risk herbicide / cultivar combinations.

INVLOED VAN VOOROPKOM-ONKRUIDDODERS OP GROEI EN OPBRENGS VAN *PHASEOLUS VULGARIS* L. EN *P. COCCINEUS* L.

deur

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Opsomming

Verskeie graangewasse, droëbone (*Phaseolus vulgaris* L. en *P. coccineus* L.), koring (*Triticum aestivum* L.), mielies (*Zea mays* L.), sojabone (*Glycine max* L.), sonneblom (*Helianthus annuus* L.) en rys (*Oryza sativa* L.) varieer t.o.v. cultivargevoeligheid teenoor onkruiddoders. Gedurende die 1982/83 seisoen is verskeie droëboonaanplantings deur asetanilied onkruiddoders beskadig (De Beer, 1988). Mennega, Nel & Le Court de Billot (1990) en Fouché (1996) het ook gevind dat plaaslike droëbooncultivars varieer in gevoeligheid teenoor onkruiddoders. Na aanleiding van verwagte verskille in gevoeligheid tussen plaaslike droëbooncultivars is 'n studie onderneem om die invloed van sekere vooropkomonkruiddoders te ondersoek op: a) die groei en opbrengs van droëbooncultivars; b) die graanopbrengs op vier

grondtipes; c) om die gebruik van chlorofil *a* fluoressensie as 'n tegniek te evalueer vir gebruik in die identifisering van cultivargevoeligheid t.o.v. onkruiddoders; d) droëboon morfologie en sel-ultrastruktuur, en e) om riglyne te stel vir roetine ondersoeke na droëboon-cultivargevoeligheid teenoor onkruiddoders. Die gevoeligheid (groei en opbrengs) van droëbooncultivars teenoor vooropkomonkruiddoders is ondersoek in 'n veldproef by die Graangewas Instituut van die Landbounavorsingsraad (LNR) in Potchefstroom (Noordwes) gedurende die 1996/97 groeiseisoen. Die gevoeligheid (gemeet in saadopbrengs) van cultivar Helderberg teenoor vooropkomonkruiddoders is gedurende 1996/97 ondersoek in veldproewe in die distrikte Chrissiesmeer, Lichtenburg, Potchefstroom en Reitz. Chlorofil-fluoressensiemetings is 21 dae na plant uitgevoer op die primêre en eerste trifoliaat blare van cultivars Kranskop en OPS-RS1, na 'n donker aanpassingsperiode van 25 min., met 'n fluoressensiemeter (Plant Efficiency Analyser, Hansatech, UK). Volledig ontvoude primêre blare van cultivar Helderberg, van een herhaling, is 14 dae na plant geoes. Die blare is gebruik om ultra-dun seksies te sny wat gebruik is om selstrukture te bestudeer m.b.v. elektron transmissie mikroskopie. Die twee rooi gespikkelde suikerbone (Kranskop en Monati) en die Alubia cultivar (Cerillos) was betekenisvol meer gevoelig as die klein wit inmaakbone (Helderberg en Teebus), carioca (Mkuzi), geel haricot (Katberg) en groot wit nierboon (SSN1) cultivars. Die groot wit nierboon was die mees verdraagsame cultivar. Die cultivars was betekenisvol meer verdraagsaam teenoor dimethenamied, imazethapir of metazachlor teen die aanbevole dosis as flumetsulam + metolachlor of metolachlor. Die dubbeldosis het 'n betekenisvolle verlaging in opbrengs tot gevolg

gehad. Kranskop en Monati en die Alubia cultivar (Cerillos) was meer gevoelig as die ander sewe cultivars wat betref bogrondse DM. Cultivar SSN1 was die mees tolerante cultivar. Die enigste betekenisvolle (P = 0.05) verlaging in opbrengs is veroorsaak deur flumioxazien op veldpersele by Lichtenburg en Reitz. Geen onkruiddoder het fluoressensie opbrengs (Fo) betekenisvol (P = 0.05) verhoog nie. Dimethenamied, flumioxazien, flumetsulam + metolachlor en metazachlor het die Fo van die primêre blare van cultivar Kranskop betekenisvol verlaag. Metazachlor het 'n soortgelyke effek gehad op die tifoliaat blare van hierdie cultivar. Flumioxazien was die enigste onkruiddoder wat die Fo van die primêre blare van cultivar OPS-RS1 betekenisvol verlaag het. Beide dimethenamied en flumioxazien het die Fo van die trifoliaat blare van OPS-RS1 betekenisvol verlaag. Imazethapir, metazachlor en metolachlor het geringe stygings (nie betekenisvol) in in die Fo van die primêre blare van OPS-RS1 tot gevolg gehad. Die Fv/Fm verhouding van die primêre blare is betekenisvol verhoog deur flumioxazin, flumetsulam + metolachlor en metazachlor. Hierdie betekenisvolle verlaging in Fo en betekenisvolle verhoging in Fv/Fm is tipies van onkruiddoders wat 'n effek het op posisie 1 van fotosintese. Verdere navorsing oor die mate waartoe onkruiddoders opbrengs kan beïnvloed, word voorgestel. Die elektronmikroskoopstudie dui op ultrastrukturele veranderinge in die blare van behandelde plante. Geen behandeling het egter drastiese veranderings in chloroplasstruktuur tot gevolg gehad nie. Al die onkruiddoders, behalwe imazethapir, het egter 'n afname in die getal stroma- en granum-lamellae tot gevolg gehad. Die styselkorrels van die behandelde plante, behalwe die aan imazethapir blootgestel, het uitgeput voorgekom en het 'n ronder vorm

gehad as die onbehandelde kontrole. Die crystae in die mitochondria van behandelde plante, behalwe imazethapir, was geswolle en het chaoties voorgekom. Hierdie veranderings is waarskynlik die gevolg van manifestasies van die inhibering van asetiel-Ko-ensiem A (CoA) wat benodig word vir chlorofil vervaardiging en ook baie belangrik is in die mitochondria gebaseerde Krebssiklus. Die doeltreffendheid van beide fotosintese en respirasie sal gevolglik negatief beïnvloed word. Dit sal plantgroei en -opbrengs benadeel. Morfologiese veranderings het ingesluit korter en verwronge stingelgroei; kleiner blare en gevolglik 'n kleiner fotosintetiese oppervlak. Imazethapyr het soos verwag geringe veranderings veroorsaak, terwyl dimethenamied, metazachlor en metolachlor die grootste veranderings tot gevolg gehad het. Hierdie studie bevestig die bestaan van differensiële verdraagsaamheid teenoor onkruiddoders by *P. vulgaris* en *P. coccineus* cultivars. Verdere navorsing, veral veldproewe, behoort nog gedoen te word om ongunstige onkruiddoder / cultivar kombinasies te identifiseer.

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