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Raising plants for herbicide evaluation; a comparison of compost types

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SUMMARY

Certain aspects of compost selection are reviewed with particular reference to the specific requirements of experimental work with herbicides. In a trial of 4 compost types in which 40 species of weed and crop plants were grown with and without additional nutrients, a diversity of reactions were recorded. No one compost was suitable for the growth of all the species. John Innes Potting compost gave the greatest shoot freshweight for 14 of the 40 species grown; University of California compost for 13; "Levington" Potting compost for 12 and "Levington" Seedling compost for one only. Many species did equally well in two or three composts. Feeding was not always beneficial; its effects depended on the particular species/compost combination involved. Weed species were generally as sensitive as crops to substrate conditions.

INTRODUCTION

The choice of a compost medium is influenced by both plant performance and such practical aspects as uniformity, availability, cost, ease of handling preparation, and storage life. The demands of a herbicide experiment will further influence compost selection.

Requirements of Herbicide work

The substrate type is of great importance, often determining the extent of herbicide activity, and basic differences in the media used have frequently been the most likely cause of inconsistencies in results obtained by various workers. This has been particularly so where inherent tolerance/susceptibility to soil-acting herbicides has been investigated (Luckwill and Caseley 1966).

Where herbicides are being assessed for foliar (shoot) activity it may be desired to minimize any uptake via roots. In such circumstances a compost having a high adsorptive capacity is required (thus inactivating any deposit penetrating the foliar canopy).

With many herbicide experiments the traditional practice of transferring from one compost to another is undesirable, and so any compost used is required to support the growth of the plant throughout; vis. from germination until final assessment, and thus possess the qualities of both the 'seedling' and the 'potting' composts of traditional usage. A delicate balance and slow release of nutrients is required in order to avoid damage in the seedling stage due to excesses, or sub-optimal growth later due to deficiency. This necessity to abandon traditional practice thus places a constraint on compost selection.

Development of New Media

a) Nutritional factors

Although much empirical work has been conducted to assess the value of various materials and mixtures for container-grown plants, it is only recently that the more fundamental properties of such media have been investigated, and the differences brought about due to transference of substrate from field conditions to the pot, appreciated (Bunt, 1962). Soil-less composts are being increasingly used although in compost trials with various commercial pot plants John Innes Potting compost No. 3 (J.I.P.) has generally given better results than peat or peat/sand mixtures (Kinnings, 1964). Attempts to emulate the performance of J.I.P. compost by increasing the fertilizer levels added to peat/sand mixtures is however meeting with some success (Anon, 1964).

Bunt (1962) concludes that nutritional factors in composts are possibly of greater importance than physical ones and recent efforts have concentrated on resolving nutritional problems which have arisen with the adoption of soil-less composts (Bunt, 1963a, 1964). In the absence of nitrifying bacteria and loam as a 'stabilizing' influence, a build-up of free ammonia may occur where organic sources of nitrogen are used.

In investigations concerning the relationship between initial compost nutrient status and plant growth and composition, the raising of nutrient levels (in John Innes potting compost) was not found to delay the need to commence feeding (Bunt, 1966). Since high nutrient levels resulted in increased plant growth the rate of depletion of such reserves was correspondingly increased and a low level of growth increment occurred under all treatments after 67 days. The time to commence feeding is therefore dependent primarily on environmental conditions.

b) Physical factors

Standardisation is held as the main advantage of peat/sand composts which are free of that variable and imprecise additive: loam. By varying the relative proportions of peat and sand it is possible to achieve a gradation in such physical properties as particle size, porosity, air and water capacity and adsorption characteristics. The composts developed at the University of California exploit these possibilities and together with the range of fertilizer mixture additives provide for a large spectrum of possible uses (Baker, (ed) 1957).

Peat, although an ideal source of organic matter for providing the adsorption sites which may be required in some herbicide work, is by no means entirely homogenous and suitable grades and types require to be selected for use as compost ingredients. Robertson (1963) has recently reviewed the factors of importance in determining the usefulness of peat for horticultural purposes and has stressed that botanical characteristics should not be considered alone. Physical and chemical qualities, such as moisture, ash contents, decomposition, grade, pH and nitrogen content, are more important but are unfortunately seldom specified.

The Present Trial

The standard compost in use at the W.R.O. for producing plants for post-emergence herbicide treatments is the University of California peat/sand mixture C.II. It has proved a useful material, being relatively sterile, easily prepared and handled and with a high organic matter content assisting inactivation of herbicide reaching the substrate.

The recent introduction of a new peat compost 'Levington Compost', available in two forms, seedling and potting, provides a further choice in compost media (Atkins, 1966), offering the further advantages of requiring no mixing and being of uniform composition. The high adsorptive capacity expected, would be a further advantage for the purpose under consideration.

Information on the behaviour in such a compost of a range of weed and crop plants (not normally grown in containers) which are used as standard types in herbicide evaluation studies is lacking. It was the purpose of the present trial to obtain such information.

MATERIALS AND METHODS

Four different composts were compared with and without supplementary liquid feeding. They were, 1) University of California mix C II (U.C.); 2) John Innes Potting compost No. 2 (J.I.P.): 3) 'Levington Compost', seedling type, (L.S.); and 4) 'Levington Compost' potting type (L.P.) The U.C. and J.I.P. composts were prepared from the following ingredients:

1. University of California C II.

   50% fine moss peat by volume
   50% fine sand by volume

   Plus per yd^3:

   - $2\frac{1}{2}$ lb hoof and horn
   - 4 oz potassium nitrate
   - 4 oz potassium sulphate
   - $2\frac{1}{2}$ lb single superphosphate
   - $7\frac{1}{2}$ lb dolomite lime
   - $2\frac{1}{2}$ lb calcium carbonate lime

2. John Innes Potting Compost No. 2

   7 parts loam by volume
   3 parts moss peat by volume
   2 parts coarse sand by volume

   Plus per yd^3:

   $10\frac{1}{2}$ lb John Innes Base fertilizer; constituents as follows:

   - 4 lb 3 oz hoof and horn
   - 4 lb 3 oz super phosphate
   - 2 lb $1\frac{1}{2}$ oz potassium sulphate

   1 lb 5 oz 5% D.D.T. dust (added to prevent damage by soil insects)

The loam used was unsterilised (thus the addition of D.D.T. was made). A pH value of 7.3 rendered the addition of ground chalk unnecessary. Mechanical analysis of the loam was as follows: coarse sand 39%, clay 15.0%, fine sand 28.0%, silt 18%, organic matter 2.5%.

3 and 4.

Levington composts*

Peat composts - constituents undeclared

The 'Levington' composts being ready for direct use required no preparation. They were, however, put through $\frac{1}{4}$ in. mesh sieve to facilitate covering of small seeds.

For each compost half of the pots received supplementary liquid feeding; the other half were not fed. A proprietary liquid fertilizer containing 16.6.6.% N.P.K., was applied at approximately weekly intervals once plants were established.

There were two replicate pots of each treatment. Forty species of wild and cultivated plants, representing several botanical groupings and including both temperate and tropical species were grown (Table I).

All plants were raised from seed apart from the perennial grasses Agropyron repens L. and Cynodon dactylon (L.) Pers. which were propagated from 1 and 2-node rhizome fragments respectively and Agrostis stolonifera L. grown from 2-node pieces of overground stolon. All seeds and planting materials were placed directly into the plastic pots ($3\frac{1}{2}$ in. diameter) in which the plants were to remain throughout the experiment. A standard plant density was achieved by thinning and varied from 2 - 8 plants per pot according to the vigour of the species (Table I).

Tropical species were grown throughout in a glasshouse with a minimum night temperature of 21°C (70°F) and with day temperatures rising to 29°C (84°F). Temperate species were germinated and spent the first six weeks from sowing/planting in the open. Species still to be harvested after this period were transferred to a cool greenhouse (10°- 18°C [50-65°F] diurnal variation) in order to escape autumn frosts.

Watering was applied from above to the compost surface.

Shoot freshweights were taken for each species once a specific growth stage had been attained (Table I). These stages represent the average development attained by the control plants at the final assessment of a herbicide selectivity test. Analysis of variance and the Duncan multiple range test were used to establish significance of differences in mean freshweights. Observations were made on such factors as germination, leaf number, leaf size,

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* ex Fisons Horticulture Limited

colour, degree of branching, plant height, and time of appearance of the inflorescence.

Table I

Species, plant density per pot and growth stages at harvest

Species/cultivar		Plant numbers per pot	Growth stage
Tropical crops			
Cotton (*Gossypium hirsutum*)	Samaru 26J	2	4-5 true leaves
Groundnut (*Arachis hypogaea*)	Natal Common	2	6-7 compound leaves
Maize (*Zea mays*)	Orla 266	2	7-8 leaves
Rice (*Oryza sativa*)	Dickwee 32B	4	4-5 leaves
Sorghum (*Sorghum vulgare*)	SB68	3	6-7 leaves
Tobacco (*Nicotiana tabacum*)	Yellow Mammoth	5	3-4 true leaves
Tropical weeds			
Cynodon dactylon		2	Shoots 6-16 in. long
Eupatorium odoratum		6	3-4 true leaf pairs
Temperate crops			
Cabbage (*Brassica oleracea capitata*)	Primo	5	2-3 true leaves
Dwarf Bean (*Paseolus vulgaris*)	The Prince	2	1-2 expanded trifoliate leaves
Field Bean (*Vicia faba*)	Blue Rock	2	5 compound leaves

Temperate crops (cont'd)		Plant numbers per pot	Growth stage
Kale (*Brassica oleracea acephala*)	Marrow Stem	5	2-4 true leaves
Lettuce (*Lactuca sativa*)	Improved Trocadero	6	5-6 true leaves
Lucerne (*Medicago sativa*)	French Provence	8	2-5 tri-foliate leaves
Oat (*Avena satava*)	Blenda	4	3-5 leaves
Onion (*Allium cepa*)	Bedfordshire champion	6	2 leaves
Parsnip (*Pastinaea sativa*)	Hollow Crown	6	3 true leaves
Pea (*Pisum sativum*)	Big Ben	2	7 compound leaves
Perennial ryegrass (*Lolium perenne*)	S.23	8	3-4 leaves on main axis, 2-4 tillers
Sugar beet (*Beta vulgaris*)	Klein E.	6	2-4 true leaf pairs
Swede (*Brassica napus*)	Bangholm	5	3-5 true leaves
Timothy (*Phleum pratense*)	S.50	8	4-5 leaves on main axis, 2-3 tillers
Wheat (*Triticum aestivum*)	Jufy I	4	4-5 leaves
White clover (*Trifolium repens*)	S.100	8	4-5 tri-foliate leaves
Temperate weeds			
Agropyron repens		4	4-5 leaves on main shoot
Agrostis stolonifera		2	6-7 leaves on main shoot, 3-4 tillers

<u>Temperate weeds</u> (cont'd)	<u>Plant numbers per pot</u>	<u>Growth stage</u>
Alopecurus myosuroides	8	3-4 leaves on main axis, 1-3 tillers
Avena fatua	4	3-5 leaves
Chenopodium album	6	8-10 true leaves. Inflorescence visible
Chrysanthemum segetum	6	12-14 true leaves
Galium aparine	6	3-5 true leaf whorls
Papaver rhoeas	8	10-11 true leaves expanded
Poa annua	8	4-6 leaves on main axis, 1-3 tillers
Polygonum lapathifolium	8	4-6 true leaves
Rumex crispus	6	4-5 true leaves
Senecio vulgaris	8	7-9 true leaves, inflorescence showing colour
Sinapis arvensis	6	4-5 true leaves
Spergula arvensis	8	plants 6-9 in. high - 1st flowers at anthesis
Stellaria media	8	plants branching - 1st flowers visible
Tripleurospermum maritimum ssp. *inodorum*	8	11-16 true leaves

RESULTS

These are interpreted on the basis of relative shoot freshweights and subjective observations of plant quality. The transformed quantitative data are presented in Table II and some interesting responses shown in Fig. 1.

<u>General effects of compost type</u>.

The overall means at the bottom of Table II show that J.I.P., U.C. and L.P. were roughly equivalent, whilst LS was a much less productive compost. This is also seen when the number of species with freshweights falling within the significant range of the maximum are calculated for each species (P=0.05). These figures are for: J.I.P. with feeding 32 spp., without feeding 27 spp.

U.C. with feeding 26 spp., without feeding 22 spp.

L.P. with feeding 27 spp., without feeding 28 spp

L.S. with feeding 12 spp., without feeding 9 spp.

J.I.P. proved a suitable compost for the majority of species. Only eight species were improved by growing in other composts, namely dwarf bean, lettuce, perennial ryegrass, timothy, white clover, A. repens, P. annua (L) and T. maritimum (L.) Kock (Matricaria maritima L.). Further application of nutrient did not lead to many significant responses with this compost. Only growth of cotton, dwarf bean and swede was significantly increased by feeding.

Seedling stands of A. myosuroides Huds. and lettuce were reduced in J.I.P.

U.C. compost was slightly less suitable for the species range than J.I.P. and 14 species failed to produce plant weights within the significant range of the maximum. Groundnut, oat, P. rhoeas L. and Sinapis arvensis L. were particularly poor. The species doing well in this compost included the small seeded grasses and legumes, e.g. perennial ryegrass, timothy, A. myosuroides, P. annua, lucerne and white clover. Feeding significantly increased growth of maize, sugarbeet, A. repens and T. maritimum.

L.S. compost gave the poorest results of the four compost types. Where treatments had a significant affect only five species, sorghum, lucerne, pea, timothy and G. aparine L., produced shoot weights not significantly different from the value for the best treatment. Of these only timothy grew well without additional fertilizer. Overall shoot weights in this compost were only circa 60% of those produced in the standard compost (U.C.) with feeding.

L.P. compost proved a suitable medium for the growth of many species particularly cereals (maize, sorghum, oat, wheat and A. fatua L.) brassicas (kale, swede) and some temperate annual weeds (G. aparine, P. lapathifolium L. R. crispus L., Sinapis arvensis, S. media L., Spergula arvensis L., and T. maritimum.) Further addition of nutrients depressed the growth of sorghum, swede and A. fatua, and only A. repens was significantly improved by feeding.

The emergence of the small-seeded weed species, P. rhoeas, Senecio vulgaris L., Sinapis arvensis and T. maritimum was reduced in L.P. and there was some further loss by death of seedlings soon after emergence; once past the early susceptible stage further loss did not occur.

Nutritional aspects.

Feeding had a significant effect on freshweight for only 15 of the species. The general effects, which varied according to compost type, have been described above. Although plant size and weight were not always affected, common symptoms of general nutritional deficiency developed in the absence of supplementary feeding. These usually first appeared in the form of early cotyledonary senescence, or yellowing and premature death of lower leaves of monocotyledons.

Table II

Mean shoot freshweight of 40 species grown in 4 compost media with and without added nutrient (as a percentage of the best treatment).

(values underlined differ significantly from best treatment (P=0.05))

Compost	J.I.P.		U.C.		L.S.		L.P.		Freshweight of best treatment in grams/plant	Coef. of variation
± Nutrient	-	+	-	+	-	+	-	+		
Cotton	67	100	56	68	37	62	64	62	13.2	11
Groundnut	100	88	42	45	55	71	46	48	9.1	18
Maize	66	79	45	88	28	54	79	100	33.0	24
Rice	95	100	82	74	59	22	17	9	1.5	19
Sorghum	83	100	69	88	32	94	80	45	9.9	22
Tobacco	100	92	55	71	33	43	60	66	5.7	10
C. dactylon	69	71	68	58	54	100	72	46	1.6	24
E. odoratum	90	100	75	72	45	69	88	85	1.5	12
Cabbage	100	99	78	81	67	84	88	72	1.8	20
Dwarf bean	63	78	57	69	47	72	88	100	18.4	8
Field bean	84	100	80	93	71	90	76	84	11.6	10
Kale	74	100	69	73	32	55	73	79	3.4	16
Lettuce	42	64	79	86	15	43	100	78	2.3	18
Lucerne	94	74	82	100	15	97	47	77	0.6	22
Oat	69	93	46	45	24	9	72	100	2.6	21
Onion	45	80	89	74	76	100	100	91	0.6	20
Parsnip	68	45	99	100	65	68	63	57	0.9	25
Pea	61	84	77	100	43	73	91	94	9.8	14
Perennial ryegrass	58	64	71	100	11	64	66	67	1.1	20
Sugar beet	83	100	32	71	20	73	86	82	2.9	16
Swede	51	84	54	70	26	51	100	60	4.4	13
Timothy	49	36	97	100	65	55	23	31	0.3	24
Wheat	74	90	53	66	28	43	95	100	2.6	15
White clover	44	42	95	100	61	54	56	65	0.6	14
A. repens	59	59	70	100	43	50	51	90	1.1	15

Table II cont'd

Compost	J.I.P.		U.C.		L.S.		L.P.		Freshweight of best treatment in grams/plant	Coef. of variation
± Nutrient	-	+	-	+	-	+	-	+		
A. stolonifera	57	55	100	54	46	49	49	60	1.7	32
A. myosuroides	41	70	99	100	3	26	76	59	1.1	39
A. fatua	93	86	53	71	10	13	100	75	1.8	13
C. album	100	98	53	61	29	39	58	78	2.2	18
C. segetum	92	83	100	69	29	17	20	39	3.0	56
G. aparine	83	100	65	97	12	75	64	82	0.9	27
P. rhoeas	100	87	44	43	26	32	62	61	1.6	15
P. annua	40	49	98	100	6	23	43	56	1.0	11
P. lapathifolium	90	99	80	100	35	57	77	92	1.4	14
R. crispus	76	100	94	92	39	41	91	78	1.8	12
S. vulgaris	52	42	48	54	44	33	91	100	3.0	37
S. arvensis	58	89	50	53	30	51	100	96	2.3	22
S. arvensis	79	84	91	90	38	63	80	100	1.6	15
S. media	79	88	64	68	36	51	89	100	2.0	11
T. maritimum	67	52	47	100	23	66	73	44	1.5	26
Means	72	80	70	79	37	56	71	73		

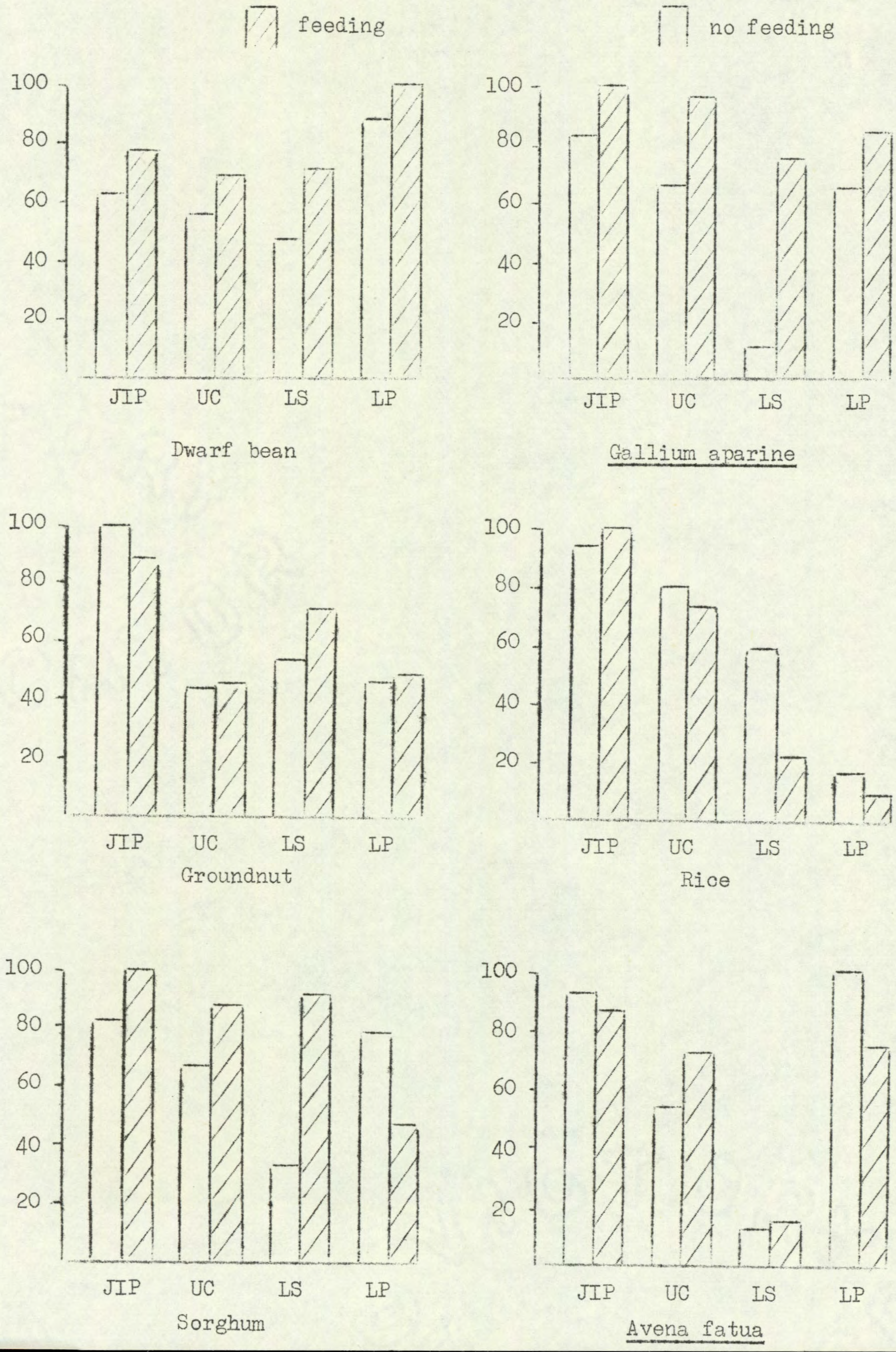
Such symptoms were apparent with cabbage (in U.C. and L.S.), cotton (U.C. and L.S.) kale (U.C., J.I.P., L.S.), maize (all composts), sugar beet (J.I.P., L.S., L.P.), swede (J.I.P., U.C.,) and tobacco (U.C., L.S.).

Dwarf bean showed a regular response to feeding in all media (Fig. Ia). Plants grown without feeding displayed symptoms ranging in severity from a uniform pale green appearance of all foliage (in J.I.P.) to severe interveinal yellowing particularly of unifoliate leaves (in U.C.).

G. aparine also responded to feeding in all media but this response was much greater with the L.S. compost (Fig. Ib), once more emphasising its low nutrient status.

Interactions between feeding and composts occurred with a few species. Thus with A. fatua, swede and T. maritimum a large decrease in freshweight occurred when plants in the L.P. composts were given extra feeding, suggesting

Fig. I. Comparative shoot fresh weight
(best treatment = 100)



an excess of nutrient imbalance in this medium. In the other composts these species generally benefited from feeding although there was no gain in J.I.P. with either A. fatua or T. maritimum. Thatthe L.P. compost contains adequate nutrient reserves is also shown by pea which gave increases in shoot weight due to feeding in the order of 23% for U.C. and J.I.P. 30% for L.S. but only 3% with L.P.

Toxic symptoms presumed due to such excesses or imbalance of nutrients were not always manifest but were prominent with groundnut, rice and sorghum, and occurred to a reduced extent with cotton, oat, and A. fatua (wild oat).

Groundnut has previously displayed severe symptoms in soil-less composts which take the form of a browning and necrosis of the whole leaflet; the lower ones being first affected. In extreme cases growth is considerably checked, while even slight symptoms render a plant useless in supplying biological data of herbicide activity. In this trial such symptoms appeared with all media except J.I.P. and, where no feeding was done in L.S. All plants in J.I.P. were healthy and vigorous while plants in L.S. although not necrotic were small (Fig. 1c) and feeding in this medium induced slight necrosis. Plants in L.P. were severely necrotic.

The upland rice cultivar Dickwee has also failed in the past to grow satisfactorily in soil-less media and in this trial severe chlorosis of the young leaves developed; these became entirely white with time, although the lowest 2-3 leaves remained unaffected. Such chlorosis occurred with all treatments apart from J.I.P.-, J.I.P.+, U.C.- and L.S.-. Growth was severely depressed in L.S.- and L.P.± (Fig. 1d). Thus only J.I.P.± and U.C.- produced plants which were of adequate quality and vigour.

With sorghum, feeding produced growth increases in all media except L.P. (Fig. 1e). Examination of plants in this compost revealed that damage to the apices had occurred after 4-5 healthy leaves had been produced. Any leaves above these were either severely chlorotic or 'scorched' in appearance. The cessation of further apical growth caused stunting and stimulated branching from lower nodes.

Cotton displayed a slight marginal yellowing on the older 2-3 leaves of plants grown in L.P.

Oats and wild oats were affected by a tip scorch of leaves in some media. This was not apparent in the case of oats in L.S. or with wild oats in J.I.P. while wheat was not affected in any treatment. This condition is frequently encountered in pot-grown cereals and is possibly related to, or influenced by, climatic conditions. The shoot growth of wild oat was significantly reduced by the L.S. media (Fig. 1f) indicating a high nutrient requirement.

Growth stages

Large differences in freshweights as brought about primarily by nutritional influences appeared to have little effect on the growth stages reached as determined by such measures as leaf numbers and the initiation of floral parts. The size of these organs rather than their numbers appear to be influenced. Thus with C. album L., although plants were considerably smaller in L.S., these bore the same leaf numbers and floral parts were at the same stage of development as the much heavier plants in other composts. *P. lapathifolium* was an exception to this; the number of expanded leaves being reduced from 5-6 to 2 per plant with a fall by 44% in freshweight. Tillering was reduced in the grasses with a corresponding reduction in freshweight and anthesis in *Spergula arvensis* was advanced.

Perennials

The initial growth of vegetatively propagated plants depends to a large extent on the condition of and food reserves in the propagatory unit; such species are less dependent on the compost media in this respect.

There were no significant effects on freshweight by either compost or feeding factors with *A. stolonifera* or *C. dactylon*, but *A. repens* was significantly increased by feeding and U.C. proved the best compost for this species.

DISCUSSION

The diversity of response obtained underlines the necessity of attaching rather less importance to the dictum of one compost for all purposes than is at present customary. If for various practical or technical reasons it is necessary to employ a single medium in the culture of a wide plant range, then it must be expected that in the case of a number of those species a sub-optimal substrate type will be used. This is acceptable providing growth is not affected to the extent of deficiency or toxicity symptoms appearing, or that severe growth reduction or the production of lush atypical growth occurs. Within these limits suitable specimens for treatment can be produced, perhaps in several alternative media which can then be selected according to specific experimental requirements.

The effects of supplementary nutrient addition can never be considered entirely independently of those of the compost medium and adjustments to a feeding programme may need to be made with this in mind, for example with rice when grown in U.C.

Since much trial is involved in arriving at correct feeding programmes for new plant/compost situations, the degree of importance to be attached to a specific plant nutrient status requires to be decided. The practical consequences of treatment with herbicides of plants, being at a sub- or supra-optimal nutritional status is only evident if deficiency/toxicity symptoms develop which obscure the damage symptoms due to the herbicide, making a valid assessment difficult or impossible. A further factor however, is the possibility of interactions between plant nutrient status and degree of tolerance or susceptibility to the herbicide. Several such cases have been demonstrated by various workers; e.g. nitrogen/2,4-D interactions (Freiberg, and Clark, 1952; Wolf, et al 1950); phosphorus/simazine interactions (Adams, 1965); and interactions of phosphorus/diuron, and phosphorus/amitrole (Upchurch et al, 1963). This all points to a need for the full consideration, specification and control of, nutrient levels available to the treated plants.

From the practical viewpoint certain points may be mentioned. The need to adjust watering with all-peat composts requires to be appreciated (Anon, 1962, 1963). The low density of loam-less composts may affect plant stability and in this trial maize tended to 'lodge' in peat composts. Generally however, the extra ease in handling due to reduced weight provides a good reason for the use of such composts.

J.I.P., U.C. and L.P. are all suitable composts providing a correct feeding programme is followed, and that the few species showing atypical responses are specially catered for. Thus groundnut and rice should only be grown in a loam-based compost, although rice may grow well in U.C. if feeding is withheld. J.I.P. and L.P. are not the best media for the germination and early growth of certain species such as lettuce and some small-seeded annual weeds. This may be related to the high nutrient status of these composts since plants at an early growth stage are known to be particularly sensitive to ammonia released in nitrification processes.

In final conclusion it must be admitted that a satisfactory and completely universal medium capable of allowing adequate germination and sustaining healthy plant growth over a reasonable period with the aid of a simple and easily executed supplementary feeding programme, is still to be discovered for the purpose under review. The new peat composts included in this trial have been produced for specific purposes or rather, stages in plant culture, and therefore cannot be expected to fulfil completely the role asked of them here. For the present time the peat/sand compost U.C.C.II provides a reasonable alternative to J.I.P. where a loamless compost is required for herbicide screening work.

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