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UNIVERSITY OF CALIFORNIA
COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION

PROJECT NO. 1686

REPORTED BY A. B. Carlton

Davis, Soils and P. N.
Campus and Division or Department

DATE January 18, 1962

Annual Summary Statement of Progress for year ending Dec. 31, 1961
This Summary is in addition to, not in place of, more complete reports of progress prepared periodically and at least once a year with a deadline of Feb. 1.

Title: Peat Land Conservation and Peat Dust Abatement

Personnel: Alan B. Carlton and cooperating research and extension staff

Principal results of year: Dust storms were monitored and compared with distribution of storms of previous years. This was the first year in the seven years of this project in which no severe dust storms occurred from westerly winds. Analysis of dust storm data combined with other meteorological information indicated that the measurable and very noticeable decrease in dust in 1961 could be attributed to the massive inter-row planting program which was instituted in the spring.

Experience in 1960 showed that it was possible to successfully interplant winter grains into asparagus during the green asparagus season by a newly developed technique. Interest on the part of the farmers and public resulted in a large expansion of inter-row planting for dust control in 1961. Over 13,000 acres of asparagus were interplanted, probably a majority of the acreage amenable to the practice. Many new techniques were tried and evaluated. Assistance was given to growers as problems arose. Although considerable acreage was planted later than now appears to be optimum for dust control or necessary from a management standpoint, 11,500 acres of interplantings eventually grew high enough for some degree of erosion and dust control. The resultant decrease in dust during the spring was clearly discerned by the public.

Variety trials for finding more suitable inter-row plants were continued. No single variety proved to be more suitable than presently recommended varieties but several barleys held promise for possible use in mixtures. No response by the interplantings was obtained from use of phosphate fertilizers. Gibberellin produced substantial elongation of inter-row grains only at high concentrations (1000 ppm) and had undesirable side affects on the foliage.

Subsidence measurements on three islands, a continuation of a long term study, were made. New techniques for studying subsidence at various levels in the profile were being developed.

Publications: INTER-ROW PLANTING IN BRIEF by Alan B. Carlton

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Dust Storms

Dust storms throughout the calendar year of 1961 were observed and classified according to severity and general wind direction. Such observations over the previous six years have shown a strikingly similar pattern of dust storm occurrence throughout the year despite differences in total dustiness and weather patterns for the various years. (See section on Dust Storms in annual reports 1955 - 1960 inclusive). These years and their dust storm patterns have, in a sense, established a "norm" against which to compare, in subsequent years, effectiveness of dust control measures applied in the Delta.

The main purpose of the dust storm observations this year was to see if any change in dust storm pattern or intensity could be noted as a result of a local program of extensive inter-row planting into white asparagus for peat dust control.

The first storm occurred on April 4, 1961 while the last was on November 11, 1961. Thirty six peat dust storms were recorded of which twenty-five were caused by generally westerly winds and hit Stockton and/or Lodi. Ten dust storms were caused by northerly winds and for the most part bypassed Stockton and Lodi. Under certain conditions a small part of the most western portion of Stockton can be hit by these northerly storms. On April 21, 1961 a mild dust storm occurred from a SW wind and missed Stockton but may have hit Lodi to some extent.

With 36 peat dust storms recorded in 1961, the year would not appear high nor particularly low in storms as compared with previous years when there were three years with fewer storms (35, 30 and 24 storms each) and three years with more storms (55,50 and 41 storms each). As has been explained on pages 35 and 36 (1956) of this report, numbers of storms recorded per year is not necessarily an indication of the "dustiness" or severity of the peat dust problem for that year. For that reason, a more thorough analysis of the storms is made in this report than in previous years to ascertain if the program of inter-row planting in 1961 had any observable effect on numbers, intensities, or distribution of dust storms.

The following data for peat dust storms for 1961 are arranged in the same manner as reports from previous years. Statements on pages 35 and 36 of the 1956 report relative to definitions and changing standards from one year to another are applicable to this report. Relative to changing standards for judging dust storm intensity, it is felt, however, that the standards for the last three years or so were probably more nearly constant than in the very early years of this project.

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Westerly dust storms hitting Stockton and/or Lodi:

Number of storms by month

	1961
January	0
February	0
March	0
April	5
May	6
June	10
July	3
August	0
September	1
October	0
November	0
December	0
Total	25

Number of storms by half-months for May and June

	1961
May 1-15	2
May 16-31	4
June 1-15	6
June 16-30	4

Tally of storms by severity:

	Number of storms						
	Total 1961	Apr.	May	June	July	Aug.	Sept.
Very severe	0	0	0	0	0	0	0
Severe	0	0	0	0	0	0	0
Moderate	3	0	1	2	0	0	0
Mild	12	2	4	4	2	0	0
Very mild	10	3	1	4	1	0	1

Distribution statistics for westerly storms: In past years dust storm distribution (percentage the year's westerly storms occurring in each month) has been compared with the average of all years, including current year, of all years then available. Since 1961 marks the beginning of a "new era" when massive dust control measures were first applied, this method of presentation will be changed slightly, using the 6 year average (1955-1960 incl.) as the basis for comparison. The following table lists the distribution of dust storms for the years 1955 thru 1961 and compares the previous 6 year average with 1961.

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Percent of year's westerly storms in each month:

	1955	1956	1957	1958	1959	1960	6-yr. ave.	1961
March	0	6	0	0	0	3	2	0
April	11	7	9	0	7	21	10	20
May	22	29	24	27	38	29	29	24
June	41	29	30	55	24	29	32	40
July	11	10	12	14	16	5	11	12
August	0	19	18	4	11	8	11	0
September	11	0	7	0	4	5	4	4
October	4	0	0	0	1	0	1	0

Although the data from the previous years have all been reported before, they are shown in this table to illustrate the variability, although not great, that occurs from year to year. It can be seen that the storm distribution throughout the year of 1961 (all categories of severity considered) is not materially different from the previous years. This similarity, in light of dust control measures in the Delta, is discussed later in the section on Dust Storms.

Northerly dust storms generally by-passing Stockton and Lodi:

There were 10 storms in this category in 1961. The usual pattern held true in that the great bulk of the northerly storms, particularly the bad ones, occurred in the fall or early spring. The one exception was the severe dust storm in early September which was the only bad northerly dust storm in September in the 7 years of this project. Although some northerly dust storms occur during the months of May and June, the bulk of them do not, so it would not be expected that inter-row planting would greatly affect the dust storm problem from northern winds.

Story Category	Dates, 1961
Severe	9/2, 10/7
Moderate	4/10, 10/28, 10/29
Mild	4/4, 4/7, 5/4, 10/8, 11/11
Very Mild	None

Distribution statistics for northerly storms: The following table of northerly dust storm distribution includes all recorded storms for the past 7 years.

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Number of northerly storms for 7 years (1955-1961) by severity:

	V. Mild	Mild	Moderate	Severe	Total	Severe & Moderate
January	0	0	0	0	0	0
February	0	0	1	0	1	1
March	1	1	2	1	5	3
April	2	4	2	2	10	4
May	1	2	3	1	7	4
June	0	1	0	1	2	1
July	0	0	0	0	0	0
August	0	1	0	0	1	0
September	1	0	0	1	2	1
October	0	4	3	3	10	6
November	1	2	1	1	5	2
December	0	0	0	2	2	2

It should be noted here that there were two errors in a similar table in the 1960 report, page 157. October severe storms should read 2 rather than 0, and October severe & moderate should read 3 rather than 1.

The fact that there is no column for very severe storms does not mean that there were no northerly storms of this severity (using criteria of western storm evaluation). It simply means that they were all lumped into the single category of severe. Actually several of the fall storms would probably fall into the very severe category, being driven by 30 MPH winds. Until 1957 only three categories were used for describing northerly storms (mild, moderate, and severe). In that year a fourth category was added - very mild, not for the purpose of splitting recorded mild storms into two categories of severity, but rather to record dustiness caused by northerly winds which otherwise would be missed. It is not felt that there is any need to split severe storms into more categories.

The greatest concentration of dust storms from northerly winds occurs in the spring months of March, April and May and in the fall, primarily October. The distribution of intense storms (moderate and severe) is very little different from that of all storms combined.

Analysis of inter-row effectiveness by dust storm observations:

As was explained earlier in this section, simple comparisons of total number of dust storms for the year, intensity, or distribution with other years are of little value in evaluating the effectiveness of a dust control measure such as inter-row planting. This is due partly to the fact that natural dustiness varies considerably from year to year because of changes in wind intensities and rain patterns, partly due to inter-row planting being effective for only about two months of the year, and partly to difficulty in accurately assessing the degree of dustiness for a given year.

Part of this problem can be solved by eliminating from the analysis northerly and southerly dust storms, few of which occur during the period in

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which inter-row planting is effective. The following table shows the number of recorded dust storms due to westerly winds by month for the various years. The six year average encompasses the years 1955-1960 inclusive, but not 1961.

Numbers of storms by months for years 1955-1961

	1955	1956	1957	1958	1959	1960	6 yr. ave.	1961
March	-	2	0	0	0	1	.5	0
April	3	2	3	0	3	8	3	5
May	6	9	8	6	17	11	9.5	6
June	11	9	10	12	11	11	10.	10
July	3	3	4	3	7	2	3.5	3
August	0	6	6	1	5	3	3.5	0
September	3	0	2	0	2	2	1.5	1
October	1	0	0	0	0	0	0	0
Totals	27	31	33	22	45	38	33	25

Except for 1958 which was very rare weatherwise (see p.p 94 and 95 of this report), having very heavy spring rains and floods and little wind, 1961 had the fewest dust storms from westerly winds. Storms of a very mild character were not recorded in 1955 and since it was considered a dusty year it is most likely that there were quite a number of very mild storms (and perhaps some mild ones too), which occurred without being recorded. It is likely, therefore that 1955 had more than two more westerly dust storms than 1961. Although this evidence points in the direction of some noticeable results from the widescale inter-row planting, it is far from conclusive.

The descriptive dust storm categories (very mild, mild, etc.)increase in dustiness in some sort of crude exponential fashion. That is, a mild storm is two or three or more times more intense than a very mild one, a moderate storm in turn is several times more intense than a mild one, etc. It follows, then, that a single severe storm causes much more erosion, dust, damage, and nuisance than several mild ones. This should be taken into account to properly evaluate any dust control measures. The following table lists total numbers of westerly dust storms by severity for the past seven years.

Number of storms by severity for years 1955-1961

	1955	1956	1957	1958	1959	1960	Ave.	1961
Very severe	-	2	0	0	1	0	.5	0
Severe	4	2	3	3	6	5	4	0
Moderate	8	6	5	4	7	5	6	3
Mild	15	14	14	8	16	17	14	12
Very mild	-	7	11	7	15	11	10	10

When the westerly dust storms are broken down into severity categories a striking fact emerges. Whereas 1961 had <u>no</u> storms in the severe and very severe categories, every other year of this study had <u>at least</u> three such storms. In addition, 1961 had fewer moderate storms than any of the other years.

Further and more accurate assessment of inter-row planting effectiveness is obtained by comparing severity of storms only in those months that inter-row

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planting can be expected to be materially useful - May and June. The following table makes this comparison.

Number of storms by severity (May and June only) 1955-1961

	1955	1956	1957	1958	1959	1960	Ave.	1961
Very severe	-	2	0	0	1	0	.5	0
Severe	3	2	2	2	6	4	3	0
Moderate	5	4	2	4	4	4	4	3
Mild	9	6	9	6	11	8	8	8
Very Mild	-	4	5	6	6	6	5.5	5

The above table, using only the months of May and June, shows essentially the same story as the previous one. There were no severe or very severe storms during these months in 1961 but at least two such storms in all other years. Except for one year, 1957, there were fewer moderate storms in 1961 than in the other years covered by this project. Even in the case of 1957, there were more moderate and severe storms combined in the month of May and June than there were in 1961.

The complete "loss" of severe storms in 1961 compared with all other years during the period which historically has been the worst dust season had a very material effect in lessening the dustiness of the season. This advantage was added to the lesser effect of fewer moderate storms. As was explained earlier, since very severe, severe, and moderate storms move so very much more dust than storms in the mild categories, a substantial lessening of these "bad" storms results in a very significant and noticeable reduction of the peat dust problem.

Although the above analysis shows a marked decrease of dustiness in 1961 and points strongly to the massive inter-row program as the responsible cause, it leaves room for the argument that this diminution of dust might have been due either to abnormally low wind velocities, unusually heavy spring rains or both. Records show that rather than being a period of low wind velocities, the spring of 1961 was a particularly windy period with many days of high wind velocities. (see climatological section of this years report by H. B. Schultz.) In addition, 1960-1961 was a below normal rainfall year. (9.17 inches as against 14.60 average) with a spring which was not abnormally wet. Based on previous years, one would have expected a particularly dusty spring with numbers and intensities of storms approximating the dustier of the previous years.

It seems reasonable to conclude from this data that the extensive inter-row program in white asparagus for dust control was effective in materially reducing the dust from the Delta in the months of May and June.

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Inter-Row Planting Experiments

The success of the community sponsored large scale inter-row planting experiment in 1960 clearly demonstrated to the general public and to the growers concerned (producers of white asparagus on wind erodible lands) two important points. First, that inter-row planting of white asparagus, properly and successfully done, very materially reduces both the erosion and the consequent dust from this important source of dust during the spring months. Secondly, it was demonstrated that the newly devised method of inter-planting early in the season into green asparagus (see pp. 159-160 of the 1960 report) made the inter-row planting feasible under most conditions occurring in the management of white asparagus. This is not to say that inter-row planting in asparagus was perfected in 1960 but it was clearly shown that the new principle (planting a single row of grain into a furrowed out center in green asparagus early in the season) could be applied to most if not all white asparagus of 7' bed width and greater.

As a result of this successful demonstration of inter-row planting, an intensive campaign was waged by growers' groups and public agencies to induce growers of white asparagus in the Delta to inter-row a substantial portion of their acreage in 1961. As a result, over 13,000 acres of white asparagus were inter-planted, probably a major portion of the land amenable to the practice. A large part of the effort of this project for 1961 was expended in assisting in the successful accomplishment of this vast increase in inter-rowed acreage. The work was primarily in the fields of education and assistance to growers inexperienced in inter-row planting, observation and development of new techniques, observation of and work on solutions to newly arising problems, and evaluation of effectiveness.

In addition to this work on wide scale inter-row planting, variety trials in field scale inter-row plantings for finding suitable inter-row grains were again planted. Fertilizer and gibberellin effects were also studied on these plantings.

Since the volunteer grain problem associated with inter-row planting occurs during the winter and following spring, complete observations on an inter-row planting program cannot be completed within the calendar year. The carry-over volunteer problem from 1960 is reported here.

Volunteer from 1960 inter-row. Volunteer barley resulting from the 1960 inter-rowing was observed throughout the winter of 1960 - 1961 until the start of the asparagus season in March 1961. Barley had volunteered in all fields except a few on one island where the asparagus had been plowed out and flooded in the summer of 1960. As was mentioned in paragraph 13), page 165 of the 1960 report, by the end of that year, the volunteer barley on a number of the islands had been partially controlled by the normal diskings following fern chopping. The normal practice of winter flooding of the asparagus fields had commenced but the amount of volunteer control resulting therefrom could not be determined.

As noted in the 1960 report, an unique situation developed with respect to the volunteering problem in that barley had sprouted in the summer

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after the last cultivation and was tall and rank when winter set in. Disking following fern chopping only partially disrupted this growth because the clumps had such large, dense, matted root systems. Although the barley was chopped by the disks and badly mangled, much of it was not killed. On one island there was no disking following the chopping of fern so this tall, rank, summer germinated barley went into the winter months completely uncontrolled.

In general, flooding did not kill out the tall, mature, summer germinated barley whether it had been disked or not. This was due mostly to not being covered completely by the flood water. In most cases, however, it was greatly weakened by the excessively wet conditions and the ravages of water fowl. The usual and necessary diskings for winter weed control and asparagus bed preparations completed the destruction of this barley to the point in all cases where there was little left and that gave no trouble at the beginning of the harvest season. Subsequent normal operations completely eliminated the small remaining barley.

Inter-row barley tends to volunteer in clumps of 5 to 40 plants because the seed heads are not shattered when the barley is disked down after the asparagus harvest season. Entire seed heads or parts tend to germinate as a unit. As a result, the plants are difficult to kill during the damp winter months if the plants have grown enough to form a dense mat or ball of soil and roots. Even if this is lifted out of the ground and partially chopped by disks, the barley plants continue to live and may even put more roots into the soil.

Wherever flooding was complete and no tall barley protruded above the water, killing of barley volunteer was complete. However, whole fields were flooded completely in only a few cases. The more usual cases were those in which the fields were unlevel with a considerable portion of them only partially flooded or not flooded at all. These resulted in cases of partially controlled volunteer barley (as a result of fern disking) over-wintering in the fields and making some but not extensive growth. This remaining barley was knocked out by normal pre-season weed control and bed preparation diskings.

The final result was that in all cases, barley volunteer had been either completely eliminated or reduced to such a negligible amount by the beginning of the asparagus harvest in March that it was no problem at all. In all cases, this control was effected by only those normal cultural operations and diskings that would have taken place regardless of the presence or absence of volunteer barley.

Variety-fertilizer-gibberellin plots. These experiments were for the purpose of finding suitable combinations of grains and treatment for inter-row planting purposes. The two most important characteristics desired in an inter-row plant are early vigor and growth rate (to withstand the rigors of the splitting and ridging operations in April) and tall stature combined with dense leafiness (for effective control of erosion). Secondary but highly desirable characteristics are late maturity with a tendency to stay green throughout the asparagus season, the inability to germinate or otherwise be a volunteer problem in the winter, and the ability to tolerate 2 4-D sprays used for weed control in the strips. Yellow dwarf resistance would also be a helpful quality.

Although certain barleys seem, at present, to be the most suitable, variety tests over the past several years have failed to discover a single variety

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which possesses to a desirable degree the characteristics just mentioned. Prior to the 1960 season, results of test plots indicated that intimate mixtures of two varieties having different characteristics tended to show the best characteristics of the component. Thus a 50-50 mixture of California Mariout barley and Swedish oats tended to have the early vigor of the barley at the start and the tall stature and delayed maturity of the oats later in the season. Field scale plantings of such mixes in 1960 were inconclusive due to problems with the particular plantings not associated with the mixture.

Field scale inter-row planting using three different mixes was tried on King Island in 1961. Approximately 50-50 by weight mixtures of Swedish oats and California Mariout barley, Onas 53 wheat and California Mariout, and Onas 53 and Rojo barley were used. The purpose of these mixtures was to combine some of the early vigor and rate of growth of the barleys with the tall stature and delayed maturity of the particular wheat and oat varieties. Planting was done on March 11, 1961 as an integral part of the regular inter-row planting. Commercial single unit, tool bar mounted, self driven planters with double disk openers were used.

By the end of the first week in April, just a few days prior to ridging for white asparagus production, there appeared to be little difference between the mixes and straight Rojo barley used for the balance of interplanting, except that the California Mariout-Swedish oat mix seemed to have slightly more growth and vigor. In the last weeks in April little difference from the suitability standpoint could be seen between field planted mixes and field planted Rojo. The barley-oat mix was, however, slightly taller and had noticeable broader leaves. A week later both mixes containing California Mariout barley were 2" above the asparagus ridges and very noticeably higher than the surrounding Rojo barley inter-row. This rapid growth of the California Mariout barley at this time (imminent approach of the worst part of the dust season) is a desirable characteristic.

By the beginning of the third week in May, the situation had reversed itself with the Mariout mixes only about 22" high and the Rojo 4" taller. The oats and wheats at this stage were not adding any height to the Mariout, the main reason for combining them with this early vigor, short stature barley. As late as June 7, this condition of the wheat and oats in the Mariout mixes being no taller than the barley still obtained. In addition, on this date the Mariout mixes appeared drier than the straight Rojo even though the oats and wheat in the mixes were still green. On June 17, at or approaching the normal end of the asparagus harvest season for which the inter-row grains are needed, none of the field planted mixes appeared superior or even equal to the straight Rojo barley. The oats-Mariout mix appeared greener because of the green oats but was generally inferior to Rojo due to the considerably shorter height of the Mariout barley and the sparse nature (due to poor stand) of the Swedish oats even though they were by that time as tall as or taller than the Rojo. The wheat of the wheat-Mariout mix was nearly as dry as the Mariout, drier than Rojo, and no taller than Rojo if as tall, Similarly, wheat-Rojo mix was slightly inferior to straight Rojo.

In this trial, all factors considered, straight Rojo barley was superior to any of the mixes. However, neither the Swedish oats nor the Onas 53

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wheat performed according to expectations based on results of previous small plot variety trials. The early vigor and growth rate of Mariout barley and the late maturity and the tall, dense stature of Swedish oats and Onas 53 wheat are desirable characteristics not contained to the desired degree in any one plant. At present, Rojo barley seems to be the best compromise with Arivat barley a suitable but less desirable substitute.

Mixture trials should be continued under a variety of conditions including a California Mariout - Rojo barley mix. Search for new, more suitable varieties should continue.

In addition to the variety mixes incorporated as regular inter-row planting on one island, smaller variety plots were again hand planted into asparagus on two islands. Included were varieties which previous trials have shown to give some promise, accepted or "control" varieties such as California Mariout, Rojo, and Arivat barleys, and new varieties. All planting was done during the last week of March. Three wheats, two oats, seven barleys, and two ryes were tested. They were observed and compared throughout the season for the properties mentioned earlier as desirable.

The barleys included California Mariout, Rojo and Arivat which were used as standards against which all other varieties were measured. In addition there were Traill, Montcalm, Kindred, and Parkland barleys. Wheats used were Pacific Bluestem, Big Club 43, and Onas 53. Curt and Swedish were the two oat varieties tried while the ryes used were Svalof Fourex (a tetraploid) and Merced.

On April 3, a few days to a couple of weeks before normal time for ridging and conversion to white asparagus, the varieties were observed for height, strength, and general vigor. At this time, all the barleys were clearly superior to all the other grains. Among the barleys, California Mariout was the best, Rojo second, and all the other barleys about equal and less vigorous than Rojo. The wheats came next with Onas 53 the strongest of them and only slightly inferior to the poorer barleys. The oats were about the same as the poorer wheats, shorter (longer coming up), but with broader, sturdier leaves. The ryes were poorest of all at this critical time, with very thin, weak, spindly leaves. At mid April the same general ranking and description held true.

In the period around the end of April and the beginning of May, California Mariout was clearly superior to all other varieties (being stiffer, more upright, and 2" taller or more than the other grains). The other barleys had only a slight edge on the other varieties which were all about the same except the Svalof Fourex Rye was slightly inferior to all the others.

At mid May, a time when full effectiveness of inter-row planting is desirable, the grain strips should be at least 20" tall, preferably much taller. Observations were made at this time to judge relative suitability and probable effectiveness for inter-row planting. The following brief descriptions from plots on King Island show susceptibility to yellow dwarf disease and stage of maturity as well as height and general leafiness and denseness. Absence of a maturity notation indicates the plant had not reached the boot stage.

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Calif. Mariout 23"-24"; headed out; leafy, dense, uniform; light yellow dwarf
Rojo 20"-25" just heading out; sl. less leafy, dense than Calif. Mar.; light Y.D.
Arivat 22"-26" heading out; considerably less leafy, dense than Rojo; light Y.D.
Traill 12"-17" very leafy, broad leaves; not yet upright, light Y.D.
Montcalm 12"-14" same as Traill but shorter
Kindred 12"-16" same as Traill
Parkland 10"-12" similar to Kindred but shorter
Onas 53 12"-14" sl. more broad leaved, stiffer, more upright than other wheats
Pac. Bluestem 10"-13" not as upright as Rojo
Big Club 43 10"-14" about like Bluestem but slightly more upright
Curt 13"-17" in boot, just heading; leaves stiff, erect (more than wheats or Swedish
Swedish 13"-15" similar to Curt but less mature, leaves less erect
Svalof Fourex 12"-16" not upright; plant 20"-30" wide; not dense
Merced 20"-26" started heading; upright, mod leafy, many stems

Observations on the same date at the Jones Tract plot showed essentially the same picture except all varieties were growing better and were 1" to 3" taller. The one exception to the general similarity was with Kindred barley. Whereas this was one of the poorer barleys in the King Island plot, it was relatively much better on Jones Tract, being taller and more upright (18"-22") than either Traill or Montcalm and was very leafy and dense.

As of mid May, only some of the barleys and perhaps Merced Rye had adequate height, stiffness and density to be suitable for inter-row planting for wind erosion control.

By the fourth week in May Merced Rye made much growth and was about 36" tall. It was not very leafy but had many upright stems, and it was felt that it should be considered for trial in a mixture with a barley.

Examination of the plots on June 17 showed that all the grains in the King Island plot were much poorer than in the Jones Tract plot. Some unknown soil condition or disease seemed to be having a very adverse affect on the growth of the plants. Previous checks of this soil for PH and total salts shed no light on the problem. As a result the wheats and Curt oats attained heights of only 13-22 inches, and the barleys were far shorter than on Jones Tract. For this reason, final comparison of the grains was made from the Jones Tract plot. By June 17 all grains had reached an adequate height for inter-row planting with most being over 30" and the ryes were 40"-50". California Mariout barley was the shortest grain at 22"-25" and not considered of adequate height by itself for optimum wind erosion control. Next in final height at 28"-32" were Rojo and Arivat barleys, the presently used varieties for inter-row planting. Although some appeared more suitable than others, all the remaining grains had sufficient height, delayed maturity, and density to warrant further testing as possible components in mixes. Except possibly for the barleys, these grains had insufficient early vigor and rate of growth to be considered as suitable for single variety inter-row planting stock. Least suitable of the varieties tested were Pacific Bluestem of the wheats, Curt of the oats, Svalof Fourex of the ryes, and Montcalm of the barleys. They should, however, be tested one more season before discarding them from consideration.

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Phosphate fertilizer was again tried to provide added early vigor and growth to the grains. It is used successfully for this purpose in wheat on the peat lands of the Delta and was found in other experiments to triple the early growth of corn. Onas 53 wheat, Swedish oat and California Mariout and Rojo barleys were used in these trials. Ground rock phosphate and single super phosphate were each drilled with the seed as a mix and single super phosphate was side dressed when the plants were in the 2 to 3 leaf stage with 6" leaves. No response was seen to any of these treatments, at any stage of growth. Perhaps placement under the seed is required for response.

A slight height response was obtained in 1960 to gibberellin spray on California Mariout barley at 100 ppm. To investigate this response further, Onas 53 wheat and California Mariout barley were treated with four levels of gibberellin spray viz. 1 ppm; 10 ppm; 100 ppm; 1000 ppm. Swedish oats and Rojo barley were similarly sprayed at the rates of 10 ppm and 100 ppm. Conditions made it impossible to spray at an earlier time so sprays were applied on May 15 at the following heights and stages of maturity. Rojo, 12"-18" in boot just heading; California Mariout 20"-23", nearly 100% headed; Onas 53, 13"-17", very early boot; Swedish, 13"-15", not yet in boot. One week later there was no visible response to any of the giberellin treatments. By June 17, California Mariout showed no response at any level of treatment. This was due, probably to the late stage of maturity at the time of treatment. Rojo responded to treatment by a 2" increase in height from both 10 ppm and 100 ppm in one plot and only from 100 ppm in the other. Onas 53 wheat gave no response at rates of 1 ppm to 100 ppm but showed a 6" response at one plot, and an 8"-10" response at the other from the 1000 ppm treatment. Accompanying this increased growth, however, were the undesired effects of hastened maturity, curled and dried leaves, lowered density. Response by Swedish oats was undetermined because of non-uniform growth of plot. These treatments should be repeated another season at a much earlier growth stage to determine if short stature plants such as Mariout can be given taller stature and slow growing plants like the wheats and oats can be caused to grow faster at an early stage.

Delta-wide inter-row planting Prior to the 1961 season a two page sheet of instructions on inter-row planting was produced and distributed to asparagus growers on peat soils. It was based on the accumulated knowledge of inter-row planting and particularly on experience with the new techniques developed in 1960. A copy of this sheet is attached on the next page as a part of this report. At a series of meetings organized by the Extension Service out on the islands, growers were given more details and shown pictures of typical equipment and methods. At these meetings the growers were urged by the District Attorney and two growers' organizations to take this opportunity to materially assist in abating the dust problem. It was recognized that all the answers to inter-row planting were not known, but only by actual experience could a grower perfect it for his own particular set of conditions.

The target period used for planting inter-row grain in 1960 was April 1 to April 15. Planting inter-row during this period was found to conflict with

conversion to white cannery asparagus and did not produce grain sufficiently high by mid May to give a high degree of erosion control. As a consequence, the recommended period for inter-row planting in 1961 was set at mid March to April 7 and growers were urged to get it in as early as possible.

Two asparagus growers on King Island and Lower Jones Tract began inter-row planting during the 2nd week of March. By April 1, slightly less than half the final inter-row acreage had been planted, with 18 to 20 growers having started planting. A week later 75% to 80% of the total to be inter-rowed had been completed. The remaining 20% to 25% was completed by about April 19, several hundreds of acres having been planted into white asparagus after conversion. In all, 25 growers on 15 tracts and islands interplanted a total of a little over 13,000 acres of white asparagus.

Ridging for white asparagus started as early as April 5, 1961 and continued at least until May 2, 1961 with many growers starting around the 8th to 12th of April. Growers who planted toward the end of March or later and converted early ran into the problem of having to convert while the barley was young, tender, and short, and was therefore easily buried in the conversion process.

By May 20, about 4700 acres (35% of total) of inter-rowed asparagus was judged high enough to be at least partially effective in erosion and dust control. Eventually about 11,500 acres grew to sufficient height and density to be more or less effective.

Observations on some of the problems encountered and techniques used are given briefly below and arranged by subject. The experience gained in this and previous years was being brought together at the end of 1961 in the form of a bulletin to assist farmers in their inter-row planting.

Planting date. The wide spread of planting dates indicated above (3/8/61 to 4/19/61) was due in part to differences in experience with inter-row among farmers and in part to lack of necessary equipment. Farmers who were unfamiliar with the techniques took longer in rigging up and modifying their equipment and tended to wait to see how their neighbors went about the new procedure. Where planters were used by three or four growers in turn, it was inevitable that the last users would be late, particularly where there were several hundred acres involved in each of the plantings. Another condition discussed later which accounted for some late planted acreage was an attempt by some growers to plant too much with one set of planters. Three growers had to postpone their planting several days because their fields were too wet. In one case the grower thought his fields were too wet as late as April 3 and another as late as March 27. Some growers feel that early conversion to white asparagus will be the usual thing from now on and that inter-row planting should begin as early as March 1. Although this early planting date has some important advantages, it is not felt that any substantial number of growers can begin this early in most years because of wetness and weed problems. Experience would indicate that the target period for beginning and completing inter-row planting should be mid March to April 1. Planting earlier than mid March is desirable if weed and moisture conditions permit.

INTER-ROW PLANTING IN BRIEF

This sheet is intended to assist you in planning for effective inter-row planting of white asparagus in 1961. It is very brief but covers most of the essentials you will need to get ready for an inter-row planting program in your 'gras this year. Inter-row planting as described here has been successful only on 7' to 8' beds. The narrower the bed the more difficult it is and the more care that is required for the method to be successful. A more complete bulletin describing inter-row planting is in preparation and will be furnished to all interested growers when completed.

Planting date. Although weather, field wetness, and weeds will dictate the date of planting to some extent, March 15 to April 7 should be the target period. Every effort should be made to begin planting as soon after March 15 as possible and to complete planting by the first week in April. The earlier the planting, the taller and more rugged the barley will be to withstand the splitting and ridging operations during conversion to white.

Preparation of ground. An important operation in inter-row planting in green asparagus prior to conversion to white is furrowing out the centers before planting the barley. The furrow should be as flat bottomed as possible and the spoils should go to the shoulders of the bed where they can be used for ridging later on. Depth of furrow will depend on the width of rows, height of green beds, and eventual height of white beds. 2" to 5" is the usual range. Enough dirt should be moved from the centers so that white ridging can be accomplished without taking out the barley or leaving it on a steep-sided ridge down the center. This furrowing may be done with a flat bottomed furrowing shovel with slanted-up wings long enough to deposit the spoils on the shoulder of the beds, tool bar mounted disks, or the front section of a splitting disk with outside blades removed. If disks are used, a duck foot chisel, heavy chain, or drag should be used to break down the sharp center ridge left by the disks.

Many centers become hard and compact due to tractor traffic. Barley will not do well under these conditions and planters will not always operate properly. Under such conditions chiseling with one or more chisel points to an adequate depth is very important.

Types of planters used. Any type of drill which will plant barley at the required rate and depth in straight, accurate rows is satisfactory. Only one drilled row per asparagus center is needed. Single disk, double disk, and chisel-type openers have been used successfully. 10' grain drills with all but two openers plugged and removed have been used but they tend to wander. Fertilizer distributors connected to chisel point openers may be used if the rate can be adjusted low enough. Homemade tool bar mounted planters using standard grain drill parts have been very successful. Commercial single unit tool bar mounted planters used for corn, sorghum, etc. should be satisfactory. Plates for several makes are available which will deliver seed at the proper rate. Covering knives or chains may be needed to properly cover the seed.

Combine operations. The furrowing, chiseling, and planting should be combined into one operation if possible to cut costs and make it easier to do a good job. The furrowing tools can be mounted on a front tool bar while planters and chisels are mounted on the rear. With some types of tools, furrowers and planters can both be mounted on the rear tool bar. It is most important that the furrowing and planting operations be done carefully and accurately. Straight barley rows exactly down the center will make ridging operations later on far easier and more satisfactory.

Varieties. Either Rojo or Arivat barley can be used but Rojo is preferred. Any planting after April 10 should either be California Mariout or a 50-50 mix of California Mariout and Arivat or Rojo. Plantings before March 15 should be a mix of Onas 53 wheat and barley so the grain strip will stay green longer. Golden Mariout and Atlas barleys are not as satisfactory as those mentioned.

Seeding rates. Seeds should be planted at the rate of about 18 to 20 seeds per foot. This will amount to about 10 lbs. per asparagus acre on 8' beds and 12 lbs. per asparagus acre on 7' beds for most barleys.

Depth of planting. Depth of planting will depend somewhat on the moisture condition of the soil but 1½" to 2" should be about right. Very shallow (1" or less) and very deep (more than 3" or 4") should be avoided. As for any crop, the barley should be planted into a good seedbed.

Weed control in grain strips. Weeds in the barley cannot be cultivated out. However, weed control has not usually been found to be necessary. If needed, 2,4-D can be used to control broad-leaved weeds in the strip. Growers have either done the spraying themselves, using 2 spray nozzles over each strip and covering 4 to 6 strips at a pass, or have had the spraying done by a custom spraying operator. The County Agricultural Commissioner should be consulted for the necessary permit to use and obtain 2,4-D.

Splitting and ridging. Splitting and ridging for conversion to white gras requires more thought and care when inter row barley is in the centers. Tractor wheels will have to be moved in so as not to run over the barley. It may not be possible to split as deeply or as widely as in previous practice. The dirt moved in splitting must not go all the way to the barley in the middle or it cannot be picked up by the ridging disks. Satisfactory splitting may require outside blades removed from disks, less disk set, or both. The narrower beds particularly may require "splash boards" at the outside disks to prevent dirt from being thrown on to the barley strip. Care and patience in finding the proper set up at this critical stage will pay off in better barley, better beds, and better dust and erosion control.

Federal cost share. For several years now, the Federal Government has approved inter-row planting as a soil conservation measure. It will pay $2.00 per acre for inter-row planting through its Agricultural Stabilization and Conservation program. Be sure to apply for this benefit before planting. Contact the San Joaquin County Agricultural Stabilization and Conservation Committee at 742 East Charter Way, Stockton, or telephone HO 2-5188.

Since a brief paper such as this cannot fully cover such a subject, any questions or requests for help in your inter-row planting problems will be welcomed by the author who can be contacted at 145 South American Street, Stockton, telephone HO 6-2581.

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Pre-plant preparation of ground. Chiseling. Experience has shown that the centers between asparagus rows frequently become hard and compact due to repeated tractor traffic. Barley will not do well under these conditions and planters will not always operate properly. Under these conditions, chiseling to loosen the soil for an adequate seed bed and to allow good root penetration is important. A number of different systems proved satisfactory in 1961. Both straight and spring shank chisels were successful although it was sometimes difficult to mount spring shanks on the front tool bars because of interference from the rear tires. Depending on conditions and equipment available, two to four chisels per center were mounted on front or rear tool bars. In one case, a separate tractor was used for chiseling prior to furrowing out and planting. Usually however, the chiseling was combined with either the furrowing operation or the planting, and chisels were generally mounted on front tool bars. Several growers mounted either chisels or small Vee sweeps on the planting tractor directly behind the rear wheels to produce a smooth and uncompacted seed bed for the planter. Chisels on the front tool bars (3 chisels per center) of the planting tractor served a dual purpose for two growers with older 7½' beds. The chisels not only loosened the center but also reformed the furrow from a deep, steep sided one to a shallower, more rounded one. The only unsuccessful use of chisels occurred when a single chisel (per center) was mounted on the rear tool bar directly ahead of the planter. A narrow groove in hard soil resulted into which the barley was planted. Spoils alongside this groove tended to bury the young barley after emergence and the soil was not effectively shattered so as to provide a good rooting medium.

Pre-plant preparation of ground. Furrowing. The furrowing out of centers between asparagus rows in green asparagus is the step that has made early and effective inter-row planting feasible. It is a very critical operation and the success of the inter-planting depends on its proper execution. Experience in 1960 proved that this step could be done in 7' and 7½' asparagus beds as well as 8' beds. This operation was more difficult, however, with the narrower beds and with older beds. It was apparent last year that techniques suitable in young or medium age 8' beds were not at all suitable to 7' beds, particularly the older ones. Because of the diversity of bed widths and bed age in 1961, many different kinds of methods were developed to do an adequate job under many different conditions. The object of furrowing is to deepen the centers 2" to 5" and move the spoils well to the sides on the shoulders of the beds without covering green asparagus on the tops of the beds. The furrow should have a broad, inverted "U" shape to allow passage of tractor tires without running on the barley to be planted. There were three general classes of equipment used for furrowing out: Trailed disks, tool bar mounted disks, and tool bar mounted furrowing shovels or crowders. These are described below.

Trailed disks drawn down the center between rows were widely used on 8' beds and proved highly satisfactory on that bed width. On narrower bed widths however, they seemed unable to produce the narrower, deeper furrows needed. Most growers using these disks pulled two such disks behind a single tractor, furrowing two centers at a time, although a few pulled only a single disk behind a small tractor. Close hitching of the disk to the drawbar was

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found important to prevent poor tracking of disks with resulting crooked or off center furrows. It is necessary to break down the ridge in the middle left by the disks. This was adequately done by either narrow harrow sections or loops of heavy chain dragged behind the disks. Two loops of chains, one longer than the other, worked better than a single loop. The disks used were front sections of splitting disks with the outside blades removed. This left four blades per half, eight blades per disk. Disks were usually adjusted so as to be fairly flat but with a considerable set to them. Centers were lowered about 3", leaving a furrow 10" - 12" below bed tops. A strip of dirt 4" - 12" wide on top of the beds remained clean of spoils.

Most 7' and 7½' asparagus was furrowed out by means of tool bar mounted disks. They were mounted on either front or rear tool bars depending on the type of tractor and whether or not other operations such as planting or chiseling were done simultaneously. In most cases, two sets were mounted, each furrowing out a center. Each set consisted of a pair of tool bar mounted ridging disks mounted back to back to throw out. Three and four blade disks were successfully used. Some growers found disks with graduated blade diameters useful. It was found that lightweight disks could be used on front tool bars but heavy disks worked best on the rear. As with the trailed disks, some form of center ridge breaker had to be provided. This was usually a spring shank mounted duck foot working just at the rear of the disks. In one case, a straight shanked duck foot mounted ahead of the disks did a fair job. Two growers on 7½' beds used a modification of the above method which, although successful, took longer because only one row at a time was worked. One set of tool bar mounted ridging disks were mounted in the usual ridging configuration but set wider than usual, the outside blades running near the middle of the asparagus centers. This method worked on two half furrows at a pass. Ridges or uneveness left in the furrows were smoothed out by chisels mounted on the planting tractor. The usual bed shape after furrowing by tool bar mounted disks consisted of a more or less flat ridge about 40" to 45" wide on top with 6" to 18" of original uncovered bed top remaining in the center. Furrow cuts of 5" to 6½" were common, but were in most cases, slightly excessive. In one case a furrow cut of 8½" left a sharp V at the bottom of a 16" deep furrow. This was partially filled in and rounded off by means of three chisels, 9" centers mounted on the front tool bar of the planting tractor. A few growers used gauge wheels on the disk carrying tool bars and this tended to stabilize the depth of cut and produced uniform furrows.

A third type of furrower was not favored by most growers although it was highly successful where designed and used properly. It was a flat bottomed furrowing shovel made by welding 8" vertical plates onto the rear edges of the knives of a Vee knife weeder. Properly angled up wings on the rear edges of these plates distributed the spoils in the desired position on the shoulders of the bed. Trials with several of these tools showed two important points. It was important that they be mounted on free floating tool bars supported and gauged by gauge wheels running in front of the shovel. Shovels mounted on fixed tool bars would not maintain an even depth of cutting and tended to cause hard and crooked steering due to changing draft from side to side. The shovels had to be adequately wide with angled up wings to properly distribute the spoils or undesirable furrow and bed shapes were obtained. They had to be essentially

custom designed for each application.

A special problem in furrowing out occurred in the case of young 8' asparagus where the beds were completely flat during the green season. Furrowing to a proper depth left a highly corrugated field which the grower feared would cause labor trouble. As a consequence, these fields were inter-planted in the flat, unfurrowed centers. Subsequent ridging for white asparagus left the barley standing on a slight ridge but this did not seem to bother the grower or the harvest labor. A similar situation occurred on an older bed where the furrowing was not deep enough. The first re-ridging after conversion left the barley on a ridge which made walking through the fields difficult.

Planters and Planting. Most of the acreage was planted by commercial single unit, tool bar mounted, self driven planters. Five different makes were used and all were satisfactory. Most had double disk openers but a few had runner openers. Of the double disk openers, some used depth bands for gauging but this seemed generally unnecessary. Depth adjustment was more readily accomplished when seed depth was gauged by planter drive wheel. Since these planters are not usually used with winter grains, suitable plates had to be found. Certain bean plates were found to be satisfactory and a sugar beet plate worked when alternate webs between cells were removed. Milo plates were found to be unsatisfactory. Cut-offs had to be modified by grinding to prevent cracking of seed. Requirements were that the unit plant about 20 seeds to the foot more or less uniformly without seed damage. Home made extensions in one case to the otherwise rather small hoppers extended the acreage planted between refills. Tool bar heights of around 18" or less are required for these planters. It was found in many cases that this did not give the tool bar adequate clearance above the tender green asparagus shoots growing on top of the ridges. As a result, drop bars (short secondary tool bars under the main tool bar) were required for mounting the planters in order for the main tool bar to clear the asparagus.

Home made, high clearance, tool bar mounted planters using standard grain drill parts were used by some growers and were satisfactory where they were of good design and well built. Gauge wheels were used by one grower on the tool bar carrying the planters in order to smooth the rough tractor track prior to passage of the planter. Chisels and small Vee sweeps were also successfully used for this purpose. Most planters had either covering knives or covering chains following the openers and these are important. Seeds were sometimes not covered adequately when these were omitted. Most growers planted their seed adequately deep. In some cases, however, seed was planted only 1/2" to 3/4" deep due to either too hard soil or poor adjustment of planters. When planted this shallow, it is sometimes difficult for the barley plant to establish its vital secondary root system. This is particularly true if planting occurs after most of the spring rains and results in stunted, sparse growth.

Most growers were able to get straight, accurate plantings, a deficiency in some plantings in previous years. As a result, problems of splitting and ridging caused by crooked or poorly gauged rows were at a minimum.

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Several growers combined operations by putting furrowing equipment on the front tool bar and planters on the rear. One tractor pass did the job and covered two rows at a time. Speed of planting and economics involved were both factors in the growers decision. Other growers thought it unwise to "put all their eggs in one basket". The thought was that with separate operations, errors in the furrowing out can be corrected or compensated for during the planting. Both methods were satisfactory from the technical standpoint, and the decision of whether or not to combine operations is largely one of personal preference and equipment available.

Observation of planting and later operations brought out two other important considerations. The first is that every effort should be made by a grower to inter-plant his fields in the same order as anticipated conversion. This will allow all the grain the longest possible time for growth before the process of splitting and ridging takes place. In a number of instances in 1961, the last fields to be inter-planted were among the first to be split and ridged. The barley was very young or just emerged and was easily damaged in the conversion process.

Similar to the above problem, is the one of a single rig (tractor with two planters) interplanting too many acres. Results in 1960 and 1961 strongly indicate that a single rig should not be expected to plant more than 400 to 600 acres. The duty of planters was two to three times that in a number of cases in 1961. The result was that planting took place over such an extended period of time that the last planted grain was too late and ran too close onto the heels of conversion or was even planted after conversion. Unforseen delays, breakdowns, and wet weather all work to greatly reduce the amount of planting one tractor can do if calculated at the rate of 60 acres per day (a good day's work with no delays).

Seed and rate. As recommended from studies over the past several years under this project, most growers used either Rojo or Arivat barleys for inter-planting. Where comparisons could be made, the Rojo appeared superior in general stature and density and at least as good in growth rate. Several growers used California Mariout. Although the early vigor and growth rate was somewhat helpful at conversion time, its final height was noticeably inferior to either Rojo or Arivat. Even so, when grown well, it was effective in erosion and dust control. Rates of 18 to 20 seeds per foot were recommended and achieved by most growers. Stands of barley at this rate seem to be satisfactory. In one case where double this rate was used the barley was obviously too thick. In another case with about 60% of this rate, stand was too thin to be of optimum value. The rate of 18 to 20 seeds per foot is close to 10 lbs. per asparagus acre on 8' row-spacing.

Splitting and ridging. These are regular asparagus culture operations when converting to white cannery asparagus and not inter-row planting operations. However, they require modification and great care when performed in inter-planted asparagus. They are critical, and in many cases the most difficult operations connected with inter-row planting. They led to more barley loss and ineffective inter-row acreage than any other factor associated with inter-row

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planting. Splitting consists of disking the bed tops to destroy unwanted green asparagus and weeds and to dry out and warm up the soil. The beds are cut into rather deeply and the dirt thrown into the centers between the rows. With barley interplantings, this throwing of dirt is restricted in that it must not cover the grain nor even come too close to the inter-row strip. The soil normally remains in this "split" or thrown out condition for a period of a few hours to a day. A tractor with ridging disks, either tool bar mounted or trailed, then brings the dirt together in a high ridge over the asparagus row. The tires of this ridging tractor frequently tended to throw the loose "split" soil into the barley row. This tendency was serious enough in several instances to require special procedures or entirely different equipment.

As has been explained previously, the narrower the beds and the older the beds, the more difficult they are to convert to white and still maintain the barley strip. Although problems arose and the splitting and disking operations were difficult in a number of cases, most growers were able to convert successfully and still leave a major portion of the inter-planted barley intact. In most of those cases where substantial amounts of barley were destroyed during converaion, closer attention to details while converting or better timing of the barley planting would have improved the grain survival and success of the inter-plantings. The following are some of the more successful methods used by growers for splitting and ridging in inter-planted asparagus.

A particularly successful method used on 8' beds used two operations for splitting. The first operation used only the front section of a 6' splitting disk with outside blades removed. The disk was adjusted flat with only a light set and the tractor used 4th gear. The second pass, several hours to a day or two later, was made by the rear section only of the 6' disk with no blades removed. The disk was angled high in the center and had a moderate set. This brought the dirt in from the barley row and produced a fair ridge. A regular trailer mounted ridging disk completed the conversion.

Several growers, in order to save young inter-row barley drastically altered the normal splitting procedure. In one case the grower omitted splitting entirely, directly ridging up the green beds while several others split only lightly by means of "belly disks" on the ridging tractor. Although the white ridges were left slightly more weedy by these procedures, no major problems arose and the growers were generally satisfied with the job.

The more usual method was the use of normal two section splitting disks with or without the outside blades removed. In one successful case of these disks on old 8' beds, outside blades were removed from the front section only which was flat and with no set. With full width disks(no blades removed) the set of the front section had to be light to prevent dirt being thrown into the barley row. This resulted in only poor to mediocre weed control where weeds were dense and tough. Many growers found it necessary to cut tractor speed during splitting in order to prevent dirt from being thrown too far. One grower rigged up splash boards on his disk to prevent this throwing tendency but they were only partially successful. Better design would probably improve performance.

In one case, the splash of loose, dry soil from the tires of the ridging tractor was so serious that the barley strip was completely buried. This problem was successfully solved by an extra operation. A small tractor of the "Cub"

class straddled the center, riding on the shoulders of the asparagus beds. By means of tool bar mounted single bladed ridging disks (two on each side of barley strip) dirt was moved away from the barley rows and slight grooves were produced for the tires of the large ridging tractor.

In one area of the Delta, many growers use steel wheeled trailer mounted ridging disks. The tread of these trailers is usually the same as the asparagus row width. As a result, the wheels roll exactly down the center between the rows just where the barley is interplanted. Most owners of such equipment found it advantageous to modify the tread to prevent running over the young barley. For most ridgers, widening the tread by extending the axle was found to be the most practical method.

Some splitting problems in 1961 could not be solved with any combination of readily available equipment. A case in point was an old asparagus planting on high 7' beds. About 90% of the barley was covered by the conversion process. Slow tractor speeds helped but were inadequate. Most of the damage was done by the front tires, not the disks. The tractor was set at minimum tread. It was found impossible to widen the tread sufficiently to straddle the barley on the outside. An important factor contributing to the problem was a pre-plant furrow which was too deep and not rounded enough on the bottom (toosteep sided). On the same ranch in similar asparagus a different type of tractor was throwing less dirt and doing a fair job. With proper pre-plant furrowing and choice of tools there is little doubt that even this difficult asparagus can be satisfactorily converted in the presence of interplantings.

A relatively new tool is being introduced into the Delta for use in asparagus farming. It is a tool bar mounted, power take-off driven Mulchivator or rotary hoe used in weed control and splitting of asparagus beds prior to ridging for white. They were used in 7½' and "tough" 7' interplanted asparagus with more success than disks under the same conditions. The spoils are well controlled and do not tend to cover the barley row. The gauge wheels are adjustable in such a way that they need not run on the asparagus and can actually act as a shield to prevent loose dirt from approaching the barley strip too closely. This tool can be of material aid in splitting and ridging the more difficult interplanted beds of old 7' and 7½' asparagus.

A factor which made conversion difficult in interplanted asparagus was the wide spread of dates for both planting and for converting. Much interrow was short and tender at conversion time. Barley at conversion ranged from 2" to 11" high. As has been pointed out earlier, earlier planting and proper order of planting the fields can assist by producing older barley better able to stand mechanical damage and partial covering by dirt.

In the past, most growers have disked and dragged the centers between asparagus beds for weed control and to provide a smooth surface for harvest labor to walk on. With inter-row, disking for weed control in the barley strip is impossible. 2,4-D spray can be used for this purpose but only one grower felt his weeds were bad enough to warrant the effort. One grower devised a special divided drag which effectively smoothed walking places alongside the barley.

The barley varieties used for inter-row planting are susceptible to the virus disease Yellow Dwarf. With it, the plants become stunted and sparse.

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In common with experience of past years, Yellow Dwarf did not substantially diminish the effectiveness of inter-row plantings. Although some plantings were affected, these were not widespread. Those fields which became infected were only partially reduced in effectiveness. In view of the experience over the past several years, Yellow Dwarf disease resistance in inter-row planting stock, although desirable, is not an important characteristic.

An ever present hazard to inter-row planting is the possibility of a strong "blow", usually from a dry north wind, when the plants are still young. Such a wind in 1961 caught several interplanted fields on one island at a critical stage in their early growth when the soil moisture supply was low. The plants were badly burned and finally died for lack of rain during the dry spring. Nearby interplantings under slightly different conditions were unaffected. A similar thing happened on two other islands where asparagus fields had sandy spots in them. Poor moisture conditions and shortage of plant nutrients caused poor stands and stunted grain which were completely ineffective in erosion control. Such locations should be interplanted earlier in the season and fertilized.

Observations of effectiveness. Since it was felt that the potential effectiveness of good inter-row planting had been adequately documented in past years by means of dust collections and wind velocity measurements, these methods were not used in 1961. Of greater importance was whether the mass use of inter-row planting would significantly and materially reduce the dust in metropolitan areas. This was determined by analysing dust storm numbers, intensities, and distribution and comparing with previous years and is reported under the heading "Dust Storms". Numerous observations out in the fields, however, demonstrated the effectiveness of inter-row planting in individual fields and the importance of good and continuous stands of the interplantings. Most fields planted prior to April 1 were up several inches above bed height by mid May and were rapidly increasing in effectiveness. As an example, on May 26 asparagus on one island with continuous stand, 24" interplantings was completely clean of any visible dust but shorter interplantings of poor stand allowed much dust from similar, adjacent asparagus. Similar observations were repeated on many islands throughout the season. Early planting contributed to early effectiveness. Barley planted before March 15 was becoming somewhat effective as early as the first week of April. This same interplanting, however, although fairly effective by mid May under normal conditions, nevertheless allowed considerable dust to blow during a strong wind which occurred shortly after ridging for white asparagus. Barley planted later would have been almost completely useless under such conditions.

Those observations all point to the importance of early planting and strong, vigorous, tall stands for maximum dust control.

Early planted Rojo barley began to dry toward the end of the first week in June and California Mariout somewhat earlier. This drying did not seem to affect the effectiveness of the interplantings to an important degree.

As in the past year, harvest labor in many cases expressed preference for working in interplanted fields. No cases were reported of workers complaining of wet working conditions due to wet barley on dewy mornings but it is recognized that this could happen as it has in the past.

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Destruction of barley. By allowing the interplanted strips to remain standing for two or three weeks after the end of the harvest season, considerable protection against wind erosion and dust can be provided until the asparagus fern is tall and dense enough to offer some protection of its own. The asparagus fields are particularly vulnerable to wind during this period because the beds have been flattened and the surface is loose, dry, and dusty. Some growers allowed the barley to stand to offer this protection while others destroyed the barley shortly after splitting the beds to allow the asparagus to go to fern. Most of the barley was destroyed eventually by disking but some was "lifted" first by Vee knife weeders. Normal cultivation during the summer for weed control further chopped the barley but in almost all cases left a certain degree of stubble mulch on the surface.

Volunteer from '61 interplantings. As happened in 1960, there were many scattered instances of volunteer germinating from capillary moisture after the last summer cultivation. Due to the dry fall however, this barley did not grow well in most cases and by fern chopping time was rather dry and generally mature. Fall rains were too light to start much volunteer until a series of rain storms the last week in November. By this time most growers had chopped and disked their asparagus fern and these operations had virtually destroyed all barley volunteer in the fields at that time. The late November rains, however, started moderate to heavy volunteer in most fields. Since fern disking had been completed, growers allowed this volunteer to grow through most of December. December flooding was incomplete enough in most fields to allow much of this barley to grow and thrive. By the end of the year it began to take on the aspects of a serious problem to many growers, some of whom began disking at this late date with only slight success. As explained earlier, barley is very difficult to destroy in mid winter with wet soils and damp weather. The volunteer problem will be closely watched through the winter and spring of 1962 to determine just how serious a problem it will turn out to be.

Public reaction. Public reaction to the widescale inter-row planting was very favorable. The people of Stockton clearly discerned a decrease in air pollution due to dust and were pleased with the cooperation and obvious effort being put forth by the growers of white asparagus.

Windbreaks

Bamboo. The bamboo continued to improve over last year but little height was added although many more culms grew to a height of about six or seven feet. The windbreak continued to be excluded from the asparagus by normal diskings and cultivations. The bamboo suffered another set back in the form of a frost the night of November 16, 1961. Temperatures in the low 20's killed 35% of the foliage but 25% of the shoots carried most of the damage. How serious this damage will be cannot be determined until the spring of 1962.

The inability of these plants to withstand cold is surprising since the species (Phyllostachys bambusoides) is reported in the literature to be hardy down to 6°F. and the parent stock came from plantings (Chico, California) regularly subject to sub-freezing temperatures. It is possible

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that there is some factor of climate or soil moisture which prevents the normal hardening off of the plants before fall frosts set in.

Other windbreak material. Three species of short stature (6'-10') willows used in Michigan as windbreaks were planted where they could be cared for during the first season prior to planting in the Delta on a test basis. At the end of 1961 they had shown poor vigor and surprisingly slow growth, perhaps because of the hot, dry summer.

New Crop Possibilities

As has been mentioned in previous reports, these are joint projects with the Agricultural Extension Service (and in the case of blueberries, also with the Pomology Department) with the San Joaquin Farm Advisors' office taking the main responsibility for the field work.

Blueberries. The main work with blueberries in 1961 was the use of black plastic for weed control. Four mil black polyethylene plastic of 10' width was put over the ridges between blueberry rows with the edges buried under 3"-4" of dirt in the berry row. There was about a foot of clearance between edges of the plastic to allow penetration of irrigation water. The plastic provided excellent weed control between rows until small animals, presumably dogs, began ripping and tearing the cover. Even with many holes, weed growth under the plastic was never great and did not present a problem. By the end of the year, however, the cover was so badly damaged as to be useless. Weed control in the blueberry rows continued to be a problem, however. Although the soil was shallow (3"-4") under much of the row due to the buried plastic, weeds continued to thrive. Hand hoeing was made difficult by the presence of the plastic sheet.

Blueberries continued to show poor growth and vigor and it was decided to study them in the Delta for only one more year.

Irrigated Pasture. The 1961 work consisted of advisory work by the farm advisor on cattle management problems in the delta.

Safflower. No specific research was done on safflower under this project but acreage was slowly increasing in the Delta assisted by the San Joaquin County farm advisor for field crops. Safflower as a crop has an advantage for dust control similar to barley or wheat in that it is planted in late winter or early spring and covers the ground during the windy spring months. If not disked, the stubble continues to give cover during the summer.

Grapes. One grower has begun growing grapes in the Delta for wine. Small experimental plantings of various varieties on mineral levee slopes and other mineral portions of the island have been growing for two years. The San Joaquin County farm advisor for grapes has been following these plantings closely and given much help and advice on varieties, training, evaluation of growth rate and vigor, need for spraying, treatment of grape stakes, etc. Harvest in 1961 produced grapes of good dry wine quality, having the desired sugar-acid ratio. Yield, although not measured, was judged to be heavy.

Results of these experimental plantings were so promising that a nursery was established in 1961 for the purpose of planting a small commercial vineyard in 1962. Varieties planted included Rubired, Calzin, Royalty, Helena, Chenin Blanc, and Samillion. The vineyard will be established on gently rolling "waste" mineral lands on the island formed on stream banks of old, meandering sloughs.

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Although vines have shown outstanding growth and vigor in experimental plantings, strong winds have presented a problem in training the vines, and the harvestable yield has suffered heavily from depredation by pheasants. Mass planting in conventional type vineyards will indicate the commercial importance of these factors. A still unknown factor is the probable higher nitrogen status of the vineyard soil as compared to the levee soil of the experimental plots. This may result in a lowered sugar status and adverse sugar-acid ratio. For this and other reasons, the commercial vineyard will be small at first and expanded with caution.

Subsidence

Lower Jones, Mildred, Bacon Islands. The measurement of the elevation along a traverse on these islands which was set up in 1922 by Walter W. Weir, Drainage Engineer (now Emeritus), California Agricultural Experiment Station, has continued under this project. A once every three year schedule has been set up, recognizing that measurements at more frequent intervals on such a long traverse have little value. The traverse was run again May 17-22, 1961. The following table shows the calculated average elevations along with the elevations from the two previous measurements for comparison. Rate of gain or loss in elevation per year since the previous measurement is listed next to the elevation.

Below sea-level elevation, in feet

Year	Lower Jones Tract	Bacon Island	Mildred Island
1955	11.90 -.19	12.44 -.21	11.32 -.14
1958	12.43 -.18	12.99 -.18	11.67 -.12
1961	12.20 4.08	13.85 -.29	11.86 -.06
Total subsidence 1922-1958	7.36	9.36	9.64
Ave. annual subsidence 1922-1958	0.20+	0.26+	0.26

Rates of change of elevations during the past three year period seem to deviate so much from previous periods as to cast some doubt on the reliability of the 1961 measurements. The greatest anomaly appears to be the apparent rise in elevation of Lower Jones Tract by a little over 2/10 of a foot. An error of closure of only 0.05 feet over the entire 8 mile traverse and on Jones Tract of only 0.02 feet would tend to indicate that the survey itself was reliable. It does not preclude of course the possibility of compensating errors. A more likely explanation for part of the error lies in the difficulty in determining where the actual soil surface is for measurement. More than half the traverse was across ridged asparagus fields with ridges sometimes being as high as 18". It is difficult while surveying to judge just how far above the bottom of a furrow the hypothetical average soil surface is. The difference in judgment of this height by different surveyors and rodmen by a few inches can grossly affect the

calculated elevations and comparisons with previous years. It is believed that previous surveys tended to use lower elevations and even the bottom of asparagus furrows for measurement. A strong effort was made in 1961 to measure the actual average elevation in furrowed land under standard compaction.

Another possible explanation for some of the apparent discrepancies lies in the manner of calculation of average elevations from surveyed elevations. Average elevation is based on a weighted average of individual elevation measurements. This may be done graphically or mathematically. The survey in the past has always eliminated from calculation elevations on mineral slough streaks which were less subject to subsidence and hence stood higher than the surrounding peat soils. As time has gone on, these areas have broadened and become less well defined. It is not certain that the same areas were eliminated from the 1961 calculation as were eliminated in the past. A search through past records and work sheets is planned to shed light on this problem and to make calculations more uniform.

The most likely explanation for the apparent rise in the elevation of Lower Jones Tract seems to lie in an error which was discovered in the 1958 survey. The field data book for that year showed an error of closure on Jones Tract of 0.40 feet. Since the error could not be found, it was spread progressively over the entire subsidence leg of the Lower Jones Tract traverse. Examination of the 1958 field data, when compared to the 1955 and 1961 surveys, strongly indicates that the 0.40 feet error occurred ahead of the subsidence leg. A thorough comparison of profiles will be made to determine just where the error lay. If, as seems likely, the error occurred before the beginning of the northbound leg of the traverse, then all elevations on Jones should have been corrected by 0.40 feet rather than progressively throughout the traverse. This will raise the calculated elevation of Lower Jones Tract in 1958 by about 0.2 feet.

Because of the above considerations, elevations for 1961 and the Lower Jones elevation for 1958 are only tentative. Speculations on the apparent lessening of subsidence rates on Lower Jones Tract and Mildred Island would be premature. It is interesting to note, however, that these two islands have been nearly 100% in asparagus during the past ten years, whereas Bacon Island has continued to have a diversified irrigated agriculture.

New methods of study. A half acre triangle of peat land on Venice Island has been set aside for use under this project to study some of the details of subsidence. It will be used for studying and perfecting methods to be used elsewhere in the Delta.

One of the goals is to measure the elevation changes of various parts of the profile to determine where the losses are occurring. One method proposed and partially tested in 1961 consisted of air core coils of wire buried in the profile. When energized by alternating current, the magnetic field strength at the surface is a function of depth. Such measurements can leave the soil completely undisturbed once the coils are installed.

Preliminary experiments in the laboratory indicated the feasibility of such an arrangement. The output of a variable frequency audio oscillator was fed into an air core coil of 50 turns and 4 inches diameter. The pickup coil was the iron core secondary of a "Ford coil". Voltage of the

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pick up was measured peak to peak on a vacuum tube voltmeter. Voltage measured ranged from 0.04 V. to 18 V. Frequencies tried ranged from 20 cps to 100,000 cps. Optimum frequency for the particular set of components was in the range of 3600 to 4000 cps. At 3700 cps, distances between coils could be accurately estimated up to 45 cm. (0.18 volts). Water and dry soil placed between coils had little effect on voltage readings. At 40 cm., voltage sensitivity was 20% change for a 5 cm change in distance. What was clearly needed for measurement of greater distances was better matching of impedances, more power input into the "active" coil, and a more sensitive meter. Use of transistor amplifiers for improving sensitivity was being investigated.

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